Department of Animal Science
Uva Wellassa University
Badulla, 90000
Sri Lanka

Tel: +94 55 355 9114
+94 55 222 6580
Fax: +94 55 2226672

Research Highlights
Department of Animal Science
2009 - 2019

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Inquiries:
Office of the Department of Animal Science:
Tel: +94 552226580
Fax: +94 55 2226672
E-mail: headans@uwu.ac.lk

Web: http://www.uwu.ac.lk/ans

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K.P.R.S. Kondasinghe[1], H.B. Jayasiri[2], J. Mallawaarachchi[3], K.P.G.K.P. Guruge[1], and E.P.D.N. Thilakarathna[1]

[1]Department of Animal Science and Export Agriculture, Uva Wellassa University, Badulla, Sri Lanka
[2]Department of Fisheries and Ocean Sciences, Ocean University, Crow Island, Sri Lanka
[3]Inland Aquatic Resources and Aquaculture Division, National Aquatic Resources Research and Development Agency, Mattakkuliya, Sri Lanka

Nannochloropsis sp. is a marine micro alga immensely valuable for aquaculture and food industry as they are rich sources of essential fatty acids, pigments, amino acids and vitamins. Present study was conducted to identify the effect of nitrogen sources on their growth and nutrient content in the cells. For the study, F/2 culture media was used as media in control culture which contains $NaNO_3$ as the source of nitrogen. The F/2 culture media was prepared by using KNO_3 (9 g l^{-1}), CH_4N_2O (Urea) (27 g l^{-1}) and NH_4Cl (47.3 g l^{-1}) as the sources of nitrogen in the culture media. Algae cultures were prepared in triplicates for all treatments and cultivated under indoor condition, maintaining the 27 °C of constant temperature and 25ppt of salinity with a continuous aeration. The results of ten days culture revealed that there was no significant difference for cell density with the time for all treatments (Two-way ANOVA: $p>0.05$). However, significant difference was found for chlorophyll-a nitrate and nitrite content which are produced by *Nannochloropsis sp.* ($p<0.05$). The significantly highest chlorophyll-a, nitrate and nitrite content were reported in the F/2 culture media with urea than that of other culture media treated with potassium nitrate and ammonium chloride. The Urea can be recommended as a more effective source of nitrogen for F/2 culture media to obtain high chlorophyll-a, nitrate and nitrite content for *Nannochloropsis* sp. culture. This study provides baseline information about the appropriate nitrogen sources which can elevate the higher productivity of *Nannochloropsis sp.*

Keywords: Nannochloropsis sp, Nitrogen sources, Nitrogen content, Cell density, Marine micro algae

Study on Diversity and Abundance of Cetaceans off Mirissa, Southern Coast of Sri Lanka

S.K. Senadeera[1], E.P.D.N. Thilakarathne[1] and U.S.P.K. Liyanage[2]

[1]Department of Animal Science, Uva Wellassa University, Badulla, Sri Lanka
[2]National Aquatic Resources Research and Development Agency, Crow Island, Mattakkuliya, Colombo 15

Sri Lanka is rich with marine cetaceans (whales, dolphins and porpoises) and mainly whale watching industry has immensely developed in Mirissa, Southern coast of Sri Lanka. But up to date surveys on cetacean populations in Southern marine water is in unsatisfactory level. Hence, a shipboard survey to identify their diversity and abundance was conducted in Southern marine water off Mirissa for 48 days during August - December 2018. 5 baleen whales (suborder *Mysticeti*) and 8 toothed whales (suborder Odontoceti) were recorded during the survey period (13 total species). Blue whale (*Balaenoptera musculus*) was the most common type of baleen whale with 443 sightings in 80^{0}10′- 80^{0}46′ E ,05^{0}55′- 05^{0}17′N and 1 - 3 range was their pod size. In addition to that, 60,4 and 3 sightings of Bryde's Whales (*Balaenoptera edeni*), Fin whales (*Balaenoptera physalus*) and Ormura Whales *(Balaenoptera omurai)* were recorded respectively. Spinner Dolphin (*Stenella longirostris*) was the highest abundant toothed whale type with 2765 sightings. In addition to that, 571 of Bottlenose Dolphin (*Tursiops truncatus)*, 125 of Stripped Dolphin *(Stenella coeruleoalba)*, 75 of False Killer Whale (*Pseudorca crassidens)*, 54 of Rissos Dolphin, (*Grampus griseus),* 30 of Pilot whale (*Globicephala macrorhyncus*), 7 of Killer Whale (*Orcinus orca*), 6 of Sperm whale (*Physeter macrocephalus*) and 3 of Humpback Whale (*Megaptera novaeangliae*) were sighted. As per whale watcher's data, Humpback Whales were recorded in Southern coast after 2015. Since the whale watching industry in Southern coast is mainly rely on Blue whale population, they are highly vulnerable group from whale watching, shipping and fishing activities. Results provide important information on the conservation status of cetaceans. Therefore, a powerful management measure is highly needed for the conservation of cetacean populations and the sustainability of whale watching industry.

Keywords: Whale, Dolphin, Mirissa, Sightings

Efficiency of Manganese Removal by *Eichhornia crassipes* and *Pistia stratiotes* from Contaminanted Water

I.D.S.T. Jayawardhana, J.A. Athula and E.P.D.N. Thilakarathne

Department of Animal Science, Uva Wellassa University, Badulla, Sri lanka

Metal pollution is a major problem of water sources used for drinking purposes. Among heavy metals, Manganese (Mn) is an essential trace element for the functioning of human, animal and plants but it leads to toxicity when it exceeds the standard level. *Phytoremediation* can be applied to remove heavy metals from aquatic environment. Floating aquatic macrophytes are used as an environmental friendly, efficient and cheap method. In presence study two aquatic plant species, *Eichhornia crassipes* (Water Hyacinth) and *Pistia stratiotes* (Water Lettuce) were used to determine the efficiency of removing Manganese. Bioassays using Water Hyacinth and Water Lettuce were carried out with de-ionized water contaminated by three concentration series (20, 40, 60 mg L^{-1}) of Manganese (Π) for a period of 24 days. Three replicates were carried out for each series. Water samples were taken from each series at one day intervals and remaining manganese were analyzed using Atomic Absorption Spectrometry technique. Variations of pH and electrical conductivity of water were also measured as same interval by standard techniques. Data were statistically analyzed using SPSS16.0 package. Both *Eichhornia crassipes* and *Pistia stratiotes* showed the highest removal efficiency at the lowest concentration of Manganese (20 mg L^{-1}). Average efficiency of manganese removal from water by *Eichhornia crassipes* and *Pistia stratiotes* were 67.61% and 80.04% respectively. Higher manganese removal efficiency was observed in *Pistia stratiotes* than *Eichhornia crassipes*. There was a significant difference ($p<0.05$) between absorbed manganese concentrations with the time in *Eichhornia crassipes,* but there was no significant difference ($p>0.05$) in *Pistia stratiotes*. The results of the study revealed that the both plants can be used to remove manganese from contaminated water. However, it is needed to conduct a pilot study for the water contaminated with manganese.

Keywords: *Eichhornia crassipes*, *Pistia stratiotes*, Manganese, Phytoremediation, Efficency

Study on Utility of *Crassostrea madrasensis* Oyster Shells for Water Quality Improvement: An Alternative for Wastewater Treatment

R.P. Senadeera[1*], G.G.N. Thushari[1] and A.P. Abeygunawardena[1]

[1]*Department of Animal Science, Uva Wellassa University, Badulla, Sri Lanka*

Oyster shell is a waste residue in sea food industry, thus waste accumulation can be minimized by reusing shells in environmental applications. Most biogenic structures act as adsorbents and biofilters in wastewater treatment. This study focuses on analysis of the potential use of *C. madrasensis* Oyster shells for removal of contaminants. Removal efficiency of heavy metals (Cu/Cd/Cr) and other physicochemical parameters in wastewater were tested in 7 treatments (different levels of thermally treated crushed oyster shells: 5 g,7 g, 9 g, 10 g, 11 g, 13 g and 15 g) for 24 hrs contact period. As results revealed, heavy metal adsorption capacity significantly changed with initial heavy metal levels and adsorbent masses ($p < 0.05$). Wastewater treated with 9g of shell powder had most efficient heavy metal removal rates for Cu (94.50 - 99.88%) and Cr (95.68 - 97.70%), while 99.16 - 99.64% of highest Cd removal rate was for wastewater treated with 11g of oyster shells. Chitin in thermally activated shells make strong adsorption capacity, thus Oyster shells act as an effective biofilter in removal of heavy metals in wastewater. Average DO increased to maximum 37.73%, while highest removal efficiency of COD was 54.80% for 15 g of shell powder after 24hrs contact period. Initial PO_4^{3-} concentration significantly decreased with increased shell powder amount ($p < 0.05$) by flocculation of phosphorous with CaO in shells during 24hrs retention period. Highest phosphate removal capacity (85.9 - 56.2%) was found to be at 15 g of shell powder, indicating potential of application in eutrophicated water. Final pH was found to be increased to 6.5 - 8.5 which is optimum pH range for aquatic life. 24 hrs is the adequate contact period to equilibrate the reactions between adsorbent and waste water, hence preventing further releasing of chemicals of shells into treated water. This study reveals potential use of *C. madrasensis* Oyster shells for wastewater treatments as a low cost, environmental friendly alternative method.

Keywords: Bio-filter, Adsorption Capacity, Physicochemical properties, Wastewater treatment, Oyster shells

Quantitative Assessment of Microplastics in Surface Water of West Coast – off Colombo, Sri Lanka

A.M.G.A.D. Athawuda[1], H.B. Jayasiri[2], S.C. Jayamanne[1], W.R.W.M.A.P Weerakoon[2], K.P.G K.P. Guruge[1], G.G.N. Thushari[1]

[1] *Department of Animal Science, Faculty of Animal Science and Export Agriculture, Uva Wellassa University of Sri Lanka*

[2] *National Aquatic Resources Research and Development Agency, Crow Island, Colombo 15*

Contamination of water with plastic litter including microplastics is a serious environmental issue. This study addressed morphological identification and quantification of microplastics (1–5 mm) with spatial variability in surface waters of 7 sites; Uswetakeiyawa, Kerawalapitiya, Dikowita, Portcity, Kollupitiya, Bambalapitiya and Wellawatta along west coast - off Colombo during August-November 2017. Marine floating litter was collected, by towing a manta net, mesh size of 300 µm and microplastics were recovered from samples using visual observation. Microplastics were confirmed by hot needle test and categorized into 4 classes based on color: black, white, colored and transparent. Sorted plastics were quantified as number and weight. Total microplastic density does not significantly change with geographical location, as distribution of microplastics has been affected by oceanic waves and winds ($p > 0.05$). Rough sea state causes mixing of surface microplastics, and altering distribution pattern over the sites during sampling period. Overall mean density of micro plastics was 0.33 ± 0.13 mg m^{-3} and 0.39 ± 0.05 No m^{-3} by weight and number of items respectively. Density of white colored microplastics significantly varied spatially, due to site-specific anthropogenic activities ($p < 0.05$). Highest number of white microplastics accumulated in water samples of Uswetakeiyawa (0.35 ± 0.06 No m^{-3}), by land based sources of tourism and recreational activities. According to results, all study sites are affected by plastic pollution and cause significant health risk on coastal biota. Microplastic contamination level in surface waters acts as a key indicator on high pollution level in west coast. Site specific management measures are suggested to mitigate microplastic pollution. Frequent estimations of microplastic density in surface water are recommended throughout year in west coast of Sri Lanka. This study provides baseline information on microplastics level in surface water of west coast.

Keywords: Microplastic density, Spatial variation, Surface coastal water, West coast, Plastic pollution

A Study on Toxicity Effect of Mancozeb Fungicide Residual on Zebrafish (*Danio rerio*) Embryo

W.C. Hiroshini[1], N.P.P. Liyanage[1*], S.C. Jayamanne[1] and D.P.N. De Silva[1]

[1]*Department of Animal Science, Uva Wellassa University, Badulla, Sri Lanka*

Mancozeb fungicide which belongs to ethelene bisdithiocarbamates (EBDCs) chemical group causes potential hazard to human and environment. Considerable amount of this pesticide leaches through soil, air and accumulate in aquatic environment. The fungicide breaks down into ethylenethiourea (ETU) within two days and residuals remain in the aquatic environment. In this study, the effect of Mancozeb residuals on zebrafish embryo was performed according to OECD guideline and investigating the lethal end points, median lethal concentrations (LC_{50}) and morphological deformities at different concentrations. Range finding test was carried out initially, using different concentrations to determine the test concentration for toxicity. The embryo toxicity test for Mancozeb residual was performed over four days period according using 16-cell stage fertilized zebrafish embryos. Ten test concentrations (5, 2.5, 1.25, 0.64, 0.32, 0.16, 0.08, 0.04, 0.02 and 0.01) mg L^{-1} Mancozeb residual was tested on 60 embryos pre-treatment. Lethality rate and morphological abnormalities were recorded at 24, 48, 72 and 96 hours post fertilization (hpf). LC_{50} for 24, 48, 72 and 96 hours of exposure to Mancozeb residual was determined as 1.4, 1.15, 1.15, 1.15 mg L^{-1} respectively. A significant difference was observed between Mancozeb residual and control group ($P < 0.05$). Coagulation of the embryo, non-detachment from the tail bud, lack of heartbeat and lack of somite formation were observed as lethal end points. Yolk sac and pericardial edema, degeneration of tail region, malformation of head and heart, retarded growth, twisted tail, shrinkage of chorion and spinal curvature were observed as morphological deformities. This study demonstrated that Mancozeb residual at 1.4 mg L^{-1} was lethal at 24 hpf level and 1.15 mg L^{-1} was lethal at 48, 72 and 96 hpf. The results indicated that Mancozeb residuals affect zebrafish (*Danio rerio*) embryo indicating its potential to cause environmental toxicity.

Keywords: Pesticide, Median lethal concentration, Fungicide, Environment, Zebrafish

Integrated Wastewater Treatment Using Water Hyacinth (*Eichhornia crassipes*) and Blue Swimming Crab (*Portunus pelagicus*) Shell Waste

U.S. Samarasinghe[1*], G.G.N. Thushari[1], A.P. Abegunawardana[1], N.P.P Liyanage[1], H.M.J.C. Pitawala[2]

[1] *Department of Animal Science, Uva Wellassa University, Badulla, Sri Lanka*
[2] *Department of Science & Technology, Uva Wellassa University, Badulla, Sri Lanka*

Natural compounds and biotic structures are used as low cost, eco-friendly methods to treat industrial wastewater by phytoremediation and adsorption/biosorption. Objective of this study was to assess applicability of readily available blue swimming crab (*P. pelagicus*) shell waste and water hyacinth (*E. crassipes*) for removing of heavy metals, organic and inorganic pollutants from wastewater. Integrated waste water systems (IWWS) with 10 different treatments of crab shell powder + water hyacinth (Shell powder as dry weight + water hyacinth as wet weight basis: 2 g & 100 g/ 2 g & 200 g/4 g & 100 g/4 g & 200 g/6 g & 100 g/6 g & 200 g/8 g & 100 g/8 g & 200 g/10 g & 100 g/10 g & 200 g) were subjected to analyse efficiency of each treatment. Efficacy of improved rate of Dissolved oxygen, removal capacity of COD, pH, TS, TDS and PO^{3-}_4 was tested in each treatment for 6-day retention period. Removal capacity of Cr, Cd and Cu levels was assessed in each treatment for 4-day contact period. According to results, both blue swimming crab shell powder levels and water hyacinth weight significantly affect on water quality improvement ($p < 0.05$). pH in all treated systems improved at 7.0, indicating optimum levels. The 4 g of crab shell powder with 200 g of water hyacinth recorded highest DO (4.1 ± 0.16), while removal rate of COD (95%), TS (72%), TDS (61%) and PO^{3-}_4 (65 - 55% for 1 - 3ppm of PO^{3-}_4 levels) were most effective at same treatment. Integrated system with 4 g crab shell +200 g water hyacinth had 92 - 78%, 86 - 77% and 96 - 86% of maximum removal efficiency for Cr, Cu and Cd respectively indicating suitability of crab shell and water hyacinth for IWWS. Metal adsorption capacity depends on adsorbent dosage, pH level, metal ion charge, initial heavy metal concentration, and ionic radius of metal. This study implies novel approach in wastewater treatment as a cost effective, environmentally acceptable method, while controlling freshwater invasive alien species load and value addition to crab shell residues.

Keywords: Phytoremediation, Biosorption, Adsorption rate, Heavy metals, Eco-friendly Wastewater Treatment Systems

Effect of Solvent Type and Extraction Time on Yield and Purity of Lotus (*Nelumbo nucifera*) Leaf Wax

H.K.A.E. Prasadika[1], N.P.P. Liyanage[1*], H.M.J.C. Pitawala[2] and J.D.M. Senevirathna[1]

[1]*Department of Animal Science, Uva Wellassa University, Badulla, Sri Lanka*
[2]*Department of Science and Technology, Uva Wellassa University, Badulla, Sri Lanka*

This study was conducted with the main objective of extracting lotus leaf wax using a simple methodology and to analyze the wax yield and purity of the extracted wax corresponding to different time treatments. Past studies have found that lotus plant leaf wax contains a mixture of aliphatic compounds mainly nonacosanol and nonacosanediols. Fresh, cleaned lotus leaves with 1 cm^2 in surface area were exposed to three organic solvents (methanol, acetone and chloroform) and time taken for the presence of light green colour (due to the extraction of chlorophyll) in the medium was recorded to find out the most efficient organic solvent. Further, contact angle measurements of water drops placed on each of the leaf samples treated with different solvents were calculated to find out the efficiency of wax extraction. Based on the results obtained from this study leaf samples with surface area of 72.41 cm^2 were exposed to chloroform by changing the dipping time duration ranging from two seconds to 30 minutes with time intervals of two seconds for the first five treatments ,15 seconds for the next three and five minutes for the last seven treatments. Extracted wax was subjected to the FTIR analysis to find out the purity of the wax. According to the results it was revealed that green colour was appeared in methanol within the first five minutes and there was no color change in the chloroform and acetone for about 30 minutes. Moreover, least change of the contact angle was shown by the leaf sample which was treated with acetone and it reveals that wax extraction was not done in an efficient manner. Chloroform is the best solvent to extract lotus leaf wax among three organic solvents used. The highest mean yield gives out by the time treatment with the dipping time of 20 minutes. And it shows that the purity decreases with the increase of the dipping time duration.

Keywords: Lotus leaf, Wax, Extraction, FTIR

Synthesis and Characterization of Local Bone Charcoal and Their Application in Waste Water Purification

W.D.K. Welgama[1], H.M.J.C. Pitawala[2], G.G.N. Thushari[1], Dinesh D. Jayasena[1]

[1]*Department of Animal Science, Uva Wellassa University, Badulla 90000, Sri Lanka*
[2]*Department of Science and Technology, Uva Wellassa University, Badulla 90000, Sri Lanka*

In recent years, the environmental pollution has increased with the improper management of solid and liquid wastes in many countries. Among the water pollutants, pollution with heavy metals has become one of the most serious environmental problems. Adsorption is one of the concepts used to remove heavy metals in waste water. Therefore, the present study was carried out for synthesis and characterization of local bone charcoals and find their application in waste water purification. Bone charcoals based on chicken and bovine bones were prepared by removing adhering meat manually and moisture at high temperature (600 ^{0}C) and characterized by several methods. The particle size and chemical composition of the prepared charcoals were obtained using digital particle size analyzer and X-ray fluorescence spectroscopy, respectively. In addition, the crystalline phases of different charcoals were determined using X-ray diffraction. The structure i.e. types of bonds and functionality was identified using FT-IR spectroscopy. The surface morphology was obtained using Scanning Electron Microscope (SEM). The results were compared with commercial active carbon. Water quality parameters in waste water including pH, dissolved oxygen (DO) level, biological oxygen demand (BOD), total dissolved solids (TDS) and chlorophyll contents and reduction in Pb content in synthetic waste water were determined after adding prepared charcoals and commercial active carbon to respective water samples. The results showed that chicken and bovine bone charcoals consist of oxygen, calcium, phosphorous, carbon, sodium, magnesium and aluminum and are mostly composed of hydroxyapatite, calcium phosphate and a small amount of carbon. Chicken and bovine bone charcoals showed similar adsorption capacity for Pb when compared with active carbon ($P > 0.05$). DO, BOD and chlorophyll content of waste water are comparable, irrespective of the charcoal type added ($P > 0.05$). However, pH and TDS content of bone charcoal added waste water are lower than those of active carbon added waste water ($P<0.05$). It can be concluded that local bone charcoal produced from chicken and bovine bones can replace commercial active carbon in waste water purification.

Keywords: Heavy metal, Adsorption, Hydroxyapatite, Bone charcoal, FT-IR spectroscopy

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Possible Effects of Climate Change Driven Sea Level Rise on Small Islet Complex of Negombo Lagoon Sea Entrance with Respect to Mangrove Floral Community and Fisheries

E.N.S. Silva, N.P.P. Liyanage, S.C. Jayamanne
Department of Animal Science, Uva Wellassa University, Badulla, Sri Lanka.

The climate change driven long term sea level rise by global warming will be a potential threat to the islet system of Negombo lagoon sea entrance which is a unique Eco geographic feature of the Sri Lankan coastline. The study was carried out to identify both ecological and socioeconomic impacts by long term sea level rise on this islet system of Negombo lagoon as a fisheries hub and ecologically important mangrove forests to the country. Three possible sea level rise scenarios by year 2100 were developed based on Intergovernmental Panel on Climate Change (IPCC) forecasts of sea level rise through Representative Concentrative Pathways (RCPs'). Inundation patterns due to sea level rise for the islet complex was projected. As ecological impacts, pneumatophore heights of *Sonneratia* spp. and *Avicennia* spp. for its distribution and inundation percentage along the Siriwardene mangrove forest due to sea level rise by 2100 were calculated. A timeline analysis for Munnakkarai islet was conducted to understand the socioeconomic significance for two selected shorelines at Munnakkarai islet with an emphasis to fisheries activities. Results have expressed that percentage land loss of Munnakkarai islet due to sea level rise scenarios I, II and III are respectively 18.21% 27.54% and 42.20% by year 2100 and projected loss of pneumatophore distribution for the scenarios I, II and III were respectively 79.7% , 99.2 % and 100%. There is a possibility of displacement, effect on fisheries and species loss in this islet complex by year 2100 due to the loss of pressure on mangrove outskirts of the island where they are possible nursery grounds of economically important fish and shellfish. In conclusion, current study has predicted negative ecological and economic impact for the islet complex due to climate change driven sea level rise by year 2100, emphasizing immediate requirement to overcome global warming nationally and internationally.

Keywords: Global climate change, Sea level rise, Lagoons, Fisheries, Mangroves

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Usability of Fish Haematological Parameters as a Biological Indicator for Freshwater Quality in Badulla District

J.M.N.M. Jayasundara, N.P.P. Liyanage, R.R.M.K.K. Wijesundera, J.D.M. Senevirathne, D.P.N. De Silva

Department of Animal Science, Uva Wellassa University, Badulla, Sri Lanka.

Water, the fundamental of life, requires continuous monitoring because water quality deteriorates over time. Fish haematological parameters respond more quickly for environmental changes with more precise results than chemical analysis which conduct periodically. As it is profitable to authenticate eco-friendly method for assessing water quality, this study was conducted to investigate the usability of fish haematological parameters as a bioindicator for assessing freshwater quality. Comparison of physico-chemical parameters of water quality was done in two inland static water bodies in Badulla district: Horabora and Mapakada reservoirs. Results of present study revealed that Transparency, Total Dissolved Solids, Biochemical Oxygen Demand (BOD), pH, Total hardness and Trace metal (As, Pb and Cu) levels were significantly different between Horabora and Mapakada reservoirs ($p<0.05$). No statistical difference was found for total alkalinity, Dissolved Oxygen level, and Surface water temperature ($p>0.05$). Both water bodies were identified as polluted in terms of Universal Water Quality Index, although Horabora reservoir was much more polluted than Mapakada reservoir by resulting higher BOD, Total Dissolved Solids, Total hardness and trace metal levels (Pb and As) with less clear water. Blood from Tilapia (*Oreochromis mossambicus*), *Labeo rohita* and *Catla catla* was used for fish haematology analysis. Red blood cell count was significantly different ($p<0.05$) between two different water bodies for each fish species. Eosinophil count showed a significant difference among two water bodies ($p<0.05$). The study revealed that a great possibility exists for using fish haematological parameters as a bioindicator for freshwater quality. Moreover, a multi-year continuous study with elaborated investigation require for clarify trends which may exist between fish haematological parameters with respect to water quality changes.

Keywords: Water quality study, Haematology, Tilapia, Eosinophil, Trace metal

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Effectiveness of Ultraviolet Filtration of Incoming Sea Water for Controlling *Vibrio* spp. in Shrimp Hatcheries in North Western Province

I.P.D.H. Pathirana[1], R.M.G.N. Rajapakshe[1], S.C. Jayamanne[1], R.M.N.P.K. Ranathunga[2]
[1]*Department of Animal Science, Uva Wellassa University, Badulla, Sri Lanka.*
[2]*Shrimp Farm Monitoring and Extension Unit, National Aquaculture, Development Authority, Batthuluoya, Sri Lanka.*

Vibrio spp. are natural micro flora that presence in marine waters are one of the main factors which responsible for larval mortality of penaeid shrimp. To avoid bacteriological problems, shrimp hatcheries adopt extensive water treatments which include effective ultraviolet filtration. But there the effectiveness of UV filters is a considerable problem. Therefore effectiveness of UV filtration of incoming sea water for controlling the *Vibrio* spp. and the management procedures that can be implemented for improving the efficiency of UV filters were studied. Ten shrimp hatcheries out of forty seven hatcheries in north western province of the country were selected. Sea water samples were taken before and after the UV filtration and were subjected to the Total Vibrio Count (TVC) test. Thiosulfate Citrate Bile salt Sucrose (TCBS) agar was used as the culture medium and pH, salinity, Ammonium-N, Nitrate-N, Nitrite-N were checked. Questionnaire survey was also conducted for collecting information regarding water treatment systems, disinfection procedures and the factors affecting on the efficiency of UV filters. According to this study there is a significant difference by considering the TVC among hatcheries and between the TVC of sea water before and after UV filtering. It was observed that salinity and pH have no significant effect on the TVC. According to questionnaire survey, although each hatchery uses the UV bulb capacities which are relevant to the water flow rates by considering the water usage volume, the effectiveness of UV filtration is not in an efficient level when comparing the mean values of TVC of sea water before and after UV filtering. According to Chi square Goodness of fit test, availability of charcoal filters, maintaining the records of hours of UV filter operation, replacing UV bulbs after its life time and routine changing of filter media in sand, charcoal and cartridge filters have significant impact on the TVC of UV filtered water. Therefore productive maintaining of the filter system is very important for the effectiveness of UV filtration.

Keywords: Water quality, Shrimp disease, Bacteriological problems, Water treatments, UV filters

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A Preliminary Study on Absorption of Heavy Metal (Lead) From Synthetic Waste Water Using Mullet (Mugil spp.) Fish Scales

H.M.S.S. Herath[1], A.G.A.W. Alakolanga[2], E.D.N.S. Abeyrathne[1]
[1]*Department of Animal Science, Uva Wellassa University, Badulla, Sri Lanka*
[2]*Department of Export Agriculture, Uva Wellassa University, Badulla, Sri Lanka*

Heavy metals are relative dense metals present in earth crust that are in high accumulation level in water bodies. Among several technologies to remove these heavy metals, biosorption is a novel concept that use in waste water facilities. This study was carried out tofind the feasibility of using mullet (*Mugilidae spp.*) fish scales as a biosorbant and find the best cost effective form of mullet fish scales to absorb heavy metal (Pb) in synthetic waste water.The effect of oven drying conditions, particle size, and dosage of fish scales and pH for the absorption of heavy metal (Pb) absorption were investigated by Atomic Absorption Spectrophotometer (AA240, 283.33 nm, Varian., Australia). The reusability was investigated with the use of nitric and hydrochloric acids. The highest mean absorption results were obtained for 3 g (98.70 ± 0.73) of damaged 1-2 cm^2 size (92.03 ± 0.51) with oven drying conditions of 80°C (99.10 ± 0.52) for 24 hours (93.93 ± 2.38). All parameters were indicated that there was a significant difference among the treatments ($P < 0.05$). In addition to that, absorption was not depended on pH and reusable ability was high with the nitric (19.83 ± 5.66) compared to hydrochloric acid (3.09 ± 0.37). But in cost effective manner new fish scales were more applicable. The observed reason for the efficient biosorption from the fish scales were the crystal structure, chemical composition of hydroxyapatite with porous structure and the highly ordered three dimensional structure of collagen. This research revealed that, there is a high potential to use mullet fish scales as a biosorbant for treat waste water in wastewater treatment facilities and it is a rapid, cost effective and high efficient biosorbant among other biosorbants.

Keywords: Heavy metal, Biosorption, Cost effective, Hydroxyapatite, Collagen

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Preliminary study on mangrove diversity in Irakkandy lagoon, Trincomalee

Krishnanantham, K. and Jayamanne, S.C.
Faculty of Animal Science and Export Agriculture, Uva Wellassa University of Sri Lanka

and

Seneviratne, Y. B. M. C. J.
GEF/IFAD-PCZRSM Project office, Department of Coast Conservation and Coastal Resource Management, Trincomalee, Sri Lanka

Introduction

The term 'mangrove' describes both the ecosystem and the plant families that have developed specialized adaptations to live in the tidal environment (Tomlinson, 1986). Preliminary study on diversity of the mangrove stands at Irakkandy lagoon (Trincomalee) was investigated to document the status of the mangrove forest and the mangrove distribution in relation to the soil salinity variation. Due to the past two decades war dilemma and present developmental activities increase the pressure on mangrove ecosystem at an alarming rate Eastern region of Sri Lanka. In addition, Tsunami has collectively contributed to the destruction of mangroves at large in the Eastern province. In this backdrop, this research aims to analyse the diversity of mangrove in the Irakkandy lagoon which further attempts to provide some suggestions to protect mangrove and its ecosystem.

Methodology

Fifteen transect lines were laid perpendicular to the shore in different sites of the lagoon and sampling was conducted from May 2014 to July 2014 at selected locations. The precise locations were determined by portable GPS unit (ETREX 10) and hydro physico-chemical parameters of each site were recorded over high tide and low tide. Whilemeasuring the mangrove diversity, Temperature and pH were checked using Multiple Test Kit (Thermo scientific) and turbidity was measured using Turbidity meter (Hach model (2100q)) in Nephelometric Turbidity Units (NTU). Salinity was measured using a Refrectrometer (Erma Hand Refractometer, Salinity: 0-100) in units parts per thousand (ppt). Data on floristic composition was identified using standard identification keys. Moreover height of the species was measured by Suunto Clinometer. Three soil samples were collected along the transect line of each site from the edge of the lagoon to end of the mangrove existence. Soil salinity was calculated according to Gibbs, 2000. Shannon-Wiener diversity index and Pielou's eveness index incorporated in the Primer software version 6.1.2 and Minitab ver.16 used for data analysis and statistical analysis.

Results and Discussion

Five different true mangrove species and nine mangrove associate plants were identified from the study site. *Avicennia marina* was the dominant species with Height (H) of 1.39± 2.54m followed by *Lumnitzera racemosa* (3.13±1.92m), *Excoecaria agallocha* (3.28±2.662 m), *Rhizophora apiculata* (3.28 ±4.79m) and *Heritiera littoralis* was found as rare species with Height of (5.27 ±2.21m) respectively.

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Figure 1 describes the calculation of Shannon–Wiener index obtained for each transect which express the number of different species in a particular area.

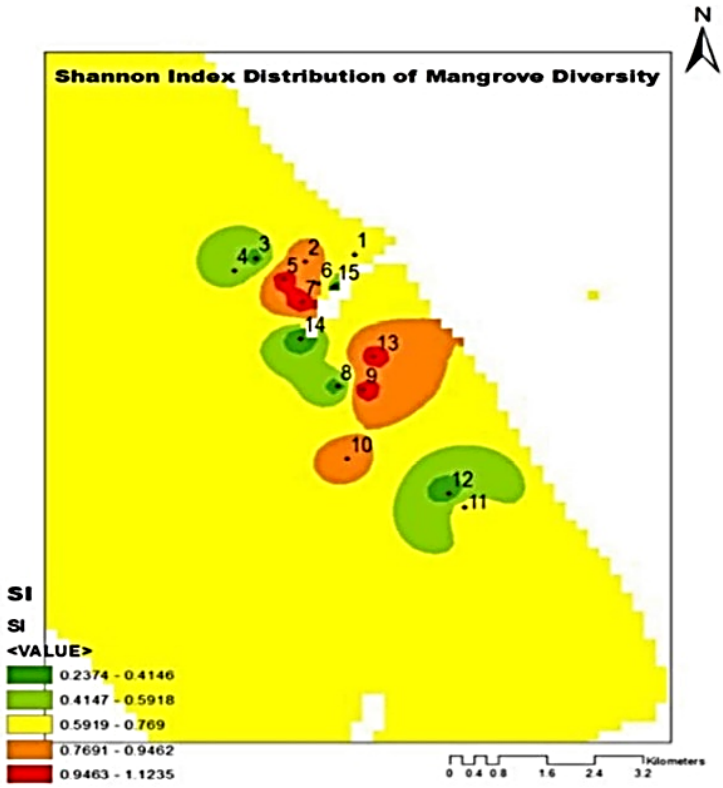

Figure 1: Shannon-Wiener Index of different Transects

The highest values (1.16) of Shannon - Wiener index shows high diversity representing diverse and equally distributed community in transect 7 while lowest value (0.22) of Shannon - Wiener index in transect 14 represents less diverse mangrove community. Transect 11 could be described as being-richer-insofar as most species present are more evenly represented by numbers of individuals since the species evenness (e) value is larger (1). Transect 14 where some species are represented by many individuals, and other species are represented by very few individuals has a low species evenness (0.16).

The wide salinity tolerance range (1-16 ppt) was observed in *Avicennia marina*. Pinto (1982) has indicated that the presence of a *Rhizophora* border on the shore may be due to its morphological adaptations in resisting water currents with the help of prop roots. Presence of a *Rhizophora* border instead of an *Avicennia* border in transect 2 may be due to the depth and slope as well as due to the lack of sandy soil and poor aeration.

The water salinity increases in high tide due to the sea water inclusion towards the lagoon and low in low tide as sea water extrude towards the sea. There is a positive moderate linear relationship between mangrove species and distance from the shore (ANOVA, $P<0.05$). In Irakkandy Lagoon, mangrove forest experiencing total diurnal inundation is dominated by *Avicennia marina* while *Excoecaria*

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agallocha dominated sites that are not completely inundated. Amarasinghe *et al.* (2013) has found that *Avicennia marina* do not grow in fresh water and may be obligate halophytes. Also *Excoecaria agallocha,* survives well in fresh water and may not have obligatory requirement for salt beyond trace amount.

There is a significant difference between soil salinity and distance from the shore (ANOVA, $P<0.05$). Low frequency and duration of tidal inundation can be cited as the probable reason for low soil salinity at the landward sites (Joshi and Ghose, 2003). As indicated by the results, decreasing salinity with increasing distance is not observed in some places. The reason can be the evaporation occurred when the temperature is raised. In contrast, frequent inundation permanently saturates the soil with seawater salt content.

There is a negative weak linear relationship between soil salinity and height of the mangrove tree (ANOVA, $P<0.05$) since low-saline mangrove forests usually show a more luxuriant growth than the high-saline ones (De Silva and de Silva, 1998). There is a negative moderate linear relationship between soil salinity and mangrove species (correlations, $P<0.05$).

Conclusion

The results of the study indicate Irakkandy lagoon consists of low biological diversity of mangroves compared to Negombo, Chilaw and Puttalam lagoons but is extremely valuable as a living mangrove forest due to its extent.

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Aquaculture and Fisheries

Aquaculture

Present Status of Export Trade of Endemic and Indigenous Freshwater Ornamental Fish Species in Sri Lanka

K.P.U.T. Egodauyana, P.C.B. Dias, J.M.D.R. Jayawardana, J.D.M. Senevirathne and N.P.P. Liyanage

Department of Animal Science, Uva Wellassa University, Badulla, Sri Lanka

Sri Lankan ornamental fish export industry has developed rapidly during last decade due to high demand. Recent surveys have indicated that wild collection of endemic and indigenous freshwater ornamental fish species has caused serious conservational issues. This study aims to evaluate the present status of export trade of endemic and indigenous fish species in Sri Lanka during 2016-2017. Secondary information on type of freshwater fish species which were exported as ornamental fishes and their levels of exporting were collected from Sri Lanka Customs. Pre-tested questionnaire was used to collect data from 15 ornamental fish exporters, including the details of restricted and prohibited species and current status of the export industry. Results of the study indicated that the exportation of endemic species and indigenous species have been reduced by 43.7% and 9.4% respectively in 2017 when compared to 2016. Highest export trend were recorded on *Garra ceylonensis*: endemic fish species (48.7%) and *Monodactylus argenteus*: indigenous species (69.6%). Only 20 species of restricted freshwater fish have exported in 2016 and not reported at 2017. The major export destinations of Sri Lankan endemic and indigenous fish was USA (22%) followed by Netherlands (18%) and Australia (10%). The results of the questionnaire survey indicated that a limited number of exporters (40%) tend to export endemic fish species due to legal barriers. Further, captive breeding of Sri Lankan endemic fish varieties (*Puntius titteya*) outside the island may threat to the ornamental fish trade of Sri Lanka. A high proportion of exporters (80%) are over depended on the wild collection which leads to overexploitation of demanded species. Further, natural habitats of the wild population are negatively affected by deforestation and environmental pollution. Therefore, improving the captive breeding for wild catch species is important to ensure the sustainability of ornamental fish trade.

Keywords: Freshwater ornamental fish, Endemic fish, Indigenous fish, Export trade, Overexploitation

Determination of Suitable Breeding Substrate for Redside Barb (*Puntius bimaculatus*) in Captive Conditions

G.K.Y.Wajiramala[1*], A.S. Mahaliyana[1], W.P.R. Chandrarathna[2] and S.C. Jayamanne[1]

[1]Department of Animal Science, Uva Wellassa University, Badulla, Sri Lanka
[2]Ornermental fish breeding and Training Center, Rambadagalle- National Aquaculture Development Authority of Sri Lanka

Redside barb (*Puntius bimaculatus*) is one of the most popular indigenous ornamental fish species, which commonly found in Sri Lanka. This species has been heavily collected from wild for aquarium trade and have a severe influence on the reduction of naturally available stocks. Development of captive breeding and larval rearing techniques are found as an effective strategy to increase commercially available stocks, which will also lead to ensure the sustainable utilization as a valuable resource. Hence, the objective of this study was to determine the suitable substrate for successful breeding of Redside barb in captivity. Three types of breeding conditions; gravels with aquatic plants, sand with aquatic plants, only aquatic plants were provided with stilled water in 60 cm x 30 cm x 30 cm size indoor glass tanks and three replicates for each treatment were used. Mature males with bright red colour stripe on their body and females which released yolked eggs, when slight pressure is applied on their abdominal region were selected as brooders for the experiment. Selected individuals were introduced into each tank at 2:1 male to female ratio. Completely Randomized Design was used as the experimental design and produced fry number was counted. Data were analyzed using one way ANOVA. Spawning was observed in all conditions and fry number varied significantly among three different substrates ($p<0.05$). The highest mean fry number was observed in the substrate of gravel with aquatic plants (195±20) compared to other 2 (fry number in the substrate which contain sand with aquatic plants: 77±39 and only aquatic plants: 33±33). Results of this study revealed that the most suitable breeding substrate for the Redside barb in indoor glass tanks was the substrate with a gravel bottom and aquatic plants.

Keywords: Redside Barb (*Puntius bimaculatus*), Captive breeding, Breeding substrate

Identification of suitable hardening medium for micro-propagated *Lagenandra thwaitesii* species in the Tilapia based aquaponic system

J.A.R.A.Jayasinghe*, A.C.W.W.M.C.L.K.Coswatte, J.D.M.Senavirathna and N.P.P.Liyanage

Department of Animal Science, Uva Wellassa University, Badulla, Sri Lanka

Lagenandra thwaitesii consider as a threatened endemic ornamental aquatic plant in family Aaraceae. Micro-propagation is a tool for large scale multiplication of these plants. High mortality experienced in transferring of micro-propagated plantlets from the laboratory to the environment is a major limitation in the production of *L. thwaitesii* at commercial scale. Aquaponic system is used for growing of various plants as a new approach to harden micro-propagated aquatic plantlets. This study focused on examining an effective hardening medium for *L. thwaitesii* in an aquaponic system. Six weeks aged uniform samples of in-vitro rooted *L. thwaitesii* plantlets were hardened by 3 different media; coconut husk, clay bricks shards and river gravels. Tilapia fish waste was used as the fertilizer from the aquaponic system, while trickling down to each section with different hardening media. The performance of plantlets in each media were measured using survival and growth parameters (number of leaves, length of roots, shoots and leaves, width of leaves, wet weight of plantlets) during five weeks of hardening period. The collected data were subjected to multivariate analysis at $P < 0.05$ level. According to the results, characteristics of hardening media significantly affect on growth performance of *L. thwaitesii*. Highest average leaf length (24.18±0.582), leaf width (10.58±0.250), root length (87.05±5.15) and wet weight (0.83±0.05) were recorded in clay brick shard medium, while maximum average number of leaves (4.05±0.189) was recorded from gravel medium. The 100% survival rate was obtained in all the hardening media. Bricks play a vital role in cation exchange, which enhances the nutrients availability for plants by increasing the growth rate of plants. Hence, clay bricks shards medium was considered as the best substrate for hardening of *L. thwaitesii* in the Tilapia based aquaponic system. This novel trend in integrated aquaculture system is useful to overcome the practical problems in micro-propagation of *L. thwaitesii* plants, as a valuable asset for ornamental aquatic plant industry.

Keywords: Acclimatization, *Lagenandra thwaitesii*, Aquatic plants, Micro-propagation, Ornamental Aquaculture, Hardening Media

Determination of the Appropriate *Oryza sativa* (Rice) Straw Fertilizer Loading Level to Enhance Survival Rate of *Catla catla* (Catla) Post Larvae

M.A.D.U. Maddumaarachchi[1*], K.M.D.M.Somarathna[2], N.P.P.Liyanage[1]

[1]Department of Animal Science, Uva Wellassa University, Badulla, Sri Lanka
[2]Aquaculture Development Center, National Aquaculture Development Authority (NAQDA), Udawalawa, Sri Lanka

Introduction of the Indian major carp species like *Catla catla* (Catla), *Labeo rohita* (Rohu) and *Cirrhinus mrigala* (Mirigal) has been resulted in a significant development in inland fisheries in Sri Lanka. Among these introduced fish species, Catla contributes to freshwater fish production in Sri Lanka significantly. One of the identified problems in Aquaculture Development Center, Udawalawa was lower survival rate of Catla post larvae at nursery stage. Hence this study was conducted to determine appropriate rice straw loading level to enhance survival rate of Catla post larvae reared in nursery tanks of 20 m^2. The experiment was conducted using a Completely Randomized Design (CRD). A preliminary fertilizing procedure was done to determine a defenitive range (75-90 g m^{-2} of dried rice straw) to conduct the experiment and the tanks were fertilized at above rates. Body weights and total lengths of post larvae were recorded at stocking and water quality parameters were recorded twice a day in each treatment. Number of survived post larvae in each treatment were recorded with the body weights and total lengths at the end of the rearing period. Recorded data were analyzed using one way ANOVA and Tukey test was used to compare mean values at 5% significance level. Total plankton count, survival rate, length gain and weight gain of post larvae were significantly different ($p<0.05$) among treatments. 80 g m^{-2} loading level of rice straw was the best treatment showing highest survival rate (66.62±0.69), greatest length gain (159.08±6.99 cm), maximum weight gain (2,576±176g) and highest mean value of total plankton count (54,910±646). Adequate amounts of planktons and proper water quality parameters act as major reasons for higher survival rate of Catla post larvae. Therefore, the loading rate of 80 g m^{-2} was found to be best among treatments for fertilizing Catla nursery tanks with rice straw to enhance survival rate.

Keywords: Rice straw, Catla post larvae, Survival rate, Plankton

Study on Effects of Substrates for Captive Breeding of Dankolapethiya (*Dawkinsia singhala*)

W.M.N.K. Walisundara[1*], A.S. Mahaliyana[1], S.C. Jayamanne[1] and W.P.R. Chandrarathna[2]

[1] Department of Animal Science, Uva Wellassa University, Badulla, Sri Lanka
[2] Ornamental fish breeding and training center, National Aquaculture Development Authority, Rambadagalle

Dankolapethiya *(Dawkinsia singhala)* is an endemic freshwater fish in Sri Lanka. This fish species has high ornamental value in export market and their natural stocks are diminishing day by day due to excessive collection by ornamental fish trade, and habitat degradation resulted by anthropogenic activities. Therefore, from the perspectives of the aquarium fish industry and conservation of the endemic fish species, captive breeding of this species is a good remedy. The objective of this study was to identify the ideal substrate under captive breeding environment. Four different substrate conditions created in cement tanks with size of 1.5 m × 0.75 m using coconut coir, sand, gravel and bare bottom and stocked fish at 2:1 male female ratio. Bottoms of the experimental tanks were fully covered with the selected substrates. Each treatment was triplicated. Height of the water column was maintained as 0.20 m. Breeding experiment was started, after 6 weeks of wild caught *Dawkinsia singhala* brooders' acclimatization period. Experimental tanks were observed closely for 7-14 days after commencement of the experiment and 63 individuals of fry were observed in the tanks with sand substrate condition. Out of four different substrates, captive breeding was only successful in experimental tanks with sandy bottom substrate, while spawning of *Dawkinsia singhala* was not successful (0%) in other experimental tanks. The study revealed that *Dawkinsia singhala* can be successfully bred under sand substrate condition in still water. This study will assist researchers to further develop captive breeding techniques for this species.

Keywords: *Dawkinsia singhala*, Endemic fish, Captive breeding, Breeding substrate

Molecular Identification and Analysis of Taxonomic Affinities of Fish Species in Selected Minor Tanks of Uva Province

T.W.R.R.L. Abeyrathne, G.G.N. Thushari, J.D.M. Senevirathna, N.P.P Liyanage, S.C. Jayamanne

Department of Animal Science, Uva Wellassa University, Badulla 90000, Sri Lanka.

Freshwater fishes are advance aquatic faunal group with diverse range of taxonomical variation. Morphometric and meristic approaches are common and traditional methods of fish identification in ecological studies. However, above methods are questioned, since several species share close external morphological characters and some species show intra-specific variations. Identification of species by molecular approaches is the novel concept in taxonomical studies. The present study was aimed for molecular identification of fish species in two selected minor tanks in Uva province; Ballawidda Wewa and Mapakada Wewa. Fish species were collected using various fishing gears and fin tip of each sample was used for DNA isolation by Promega wizard genomic DNA kit. Approximately 500 bp partial mitochondrial genome of 16s rRNA region was amplified and sequenced. The obtained sequences were edited by Codon code aligner and compared with the GenBank database available in the National Center for Biotechnology Information to identify at the species level. Phylogenetic tree was produced using Neighbor-Joining (NJ) statistical method by MEGA.7 to detect taxonomic affinities. Total of eight species which belong to three orders (Siluriformes, Perciformes, Cypriniformes) within five families (Bagridae, Heteropneustidae, Cichlidae, Channidae, Cyprinidae; subfamily Cyprininae and Rasborinae) were accurately recognized with more than 95% identification level. Three main clads were resulted in the phylogenetic tree. *Dawkinsia singhala, Cirrhinus mrigala, Puntius thermalis* and *Amblypharygodon melettinus* species grouped under clade I while *Mystus zeylanicus* and *Heteropneustes fossilis* grouped in clade II. *Channa striata* along with *Etroplus suratensis* formed the clade III. *Cirrhinus mrigala* is identified as the only introduced food fish species in this study which is categorized under the clade I group. According to the phylogenetic tree, the collected fish samples from minor tanks of Sri Lanka are mostly related with Indian fish species. Most of species share common morphological and genetic characters in comparable environmental conditions. It is recommended to conduct detailed phylogenetic, biochemical and ecological interactions, using more samples to realize genetic relatedness between introduced and native fish species in reservoirs of Sri Lanka.

Keywords: Biodiversity, Freshwater Fishes, 16S rRNA, Phylogeny

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Impact of Implementation of Better Management Practices on *Penaeus monodon* Farming in Puttlam Zone, Sri Lanka.

P.S. Peduruhewa[1], J.A. Athula[1], R.M.N.P.K. Ranathunga[2], J.M. Asoka[2]

[1]*Department of Animal Science, Uva Wellassa University, Badulla 90000, Sri Lanka*
[2]*National Aquaculture Development Authority of Sri Lanka. No 49/1, New Parliament Rd, Pelawatte, Battaramulla, 10120, Sri Lanka*

Penaeus monodon farming is the main brackish water, commercial scale aquaculture practice, which targets the export market in Sri Lanka. However, it has been suffering from disease outbreaks due to the unplanned aquaculture development in the North Western area of the country. To overcome these issues National Aquaculture Development Authority has introduced best management practices to farmers for the convenience of management and monitoring. Shrimp farming area of North Western Province has been classified into five major zones as Chilaw, Arachchikattuwa, Mundalama, Kalpititya and Puttlam. These major zones were divided into 33 sub zones. This study was carried out to investigate the level of implementation of better management practices in the six sub zones and to assess the relationship between better management practices and yield per hectare in Puttlam Zone. Among 120 farms of the Puttlam Zone, 30 individual farms representing six sub zones were selected randomly. Level of implementation of better management practices, yield per hectare, and disease occurrence data were collected through a self-administered questionnaire and farm observation. According to the Principal Component Analysis, farms in Puttlam zone can be categorized into four major groups based on the level of implementation of better management practices as 26.66% optimum level implementation, 40% average level implementation, 10% Minimum level implementation and 23.33% dissatisfied level implementation. Further, levels of implementation of better management practices referring to the sub zones are 57.14%, 42.8%, 25%, and 25%, respectively for the sub zones of Sewwanthiwu, Aneikutti, Manalthiwu and Wadathamunei. Descriptive analysis reveals that the levels of implementation of better management practices in Mee oya and Poorwasikuda sub zone are 7.66% and 3.5% respectively. The significant positive relationship was observed between level of implementation of better management practices and yield per hectare ($r = 0.810$, P-value = 0.000). Further, significant negative relationship was observed between level of implementation of better management practices and disease occurrence ($r = -0.837$, P-value = 0.035).

Keywords: Better Management Practices, *Penaeus monodon*, Sub zone

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Examine the Appropriate Ovulation Time to Determine Latency Period of Golden Tinfoil Barb (*Barbonymus schwanenfeldii*) Using Ovaprim™

W.A.U. Isharini[1], E.D.M. Epasinghe[2], T.A.D.W. Karunaratne[2], A.M.A.N. Adikari[2], N.P.P. Liyanage[1]

[1]*Deparment of Animal Science, Uva Wellassa University, Badulla, Sri Lanka.*
[2]*National Aquatic Resources Research and Development Agency, Crow Island, Colombo 15, Sri Lanka.*

Fertility of the Golden Tinfoil Barb is very low when they are subjected to induced breeding practices. The research was carried out to determine the appropriate ovulation time for maximizing the fertility rate of Golden Tinfoil Barb, *Barbonymus schwanenfeldii*. Induced spawning of *Barbonymus schwanenfeldii* was conducted at different Ovaprim (sGnRHa and Domperidone) dose and latency period combinations to observe the appropriate ovulation time to increase the fertility. For the purpose, three doses of Ovaprim (0.4, 0.6 and 0.8 mL/kg of body weight) and three latency periods (4, 6 and 8 hours) were considered in nine combinations. Males were injected with half of dosage from female. Induced of breeding was carried out in the hatchery and same water source was used for maintaining the equal condition. After the injection, biopsy tests were performed for all the females after 4, 6 and 8 hours from the injection to detect the moment of ovulation. After eight hours, mean egg diameter was 982.81 ± 48.49 µm, germinal vesicle had broken down, follicle had already removed and ovulation had occurred. When ovulation was observed, hand stripping and then artificial fertilization was carried out. One hour after fertilization, between 40 and 60 eggs of three samples were taken from the hatching jar for each dosage and eggs were counted to calculate percentage of fertilization. Although all ovulation times were recorded in approximately eight hours after the injection, the recorded fertility rates were different. 4% fertility rate was recorded with the 8 ± 2.0 hours in 0.4 mL/kg, while it was 80% with the 8 ± 0.5 hours in 0.6 mL/kg of Ovaprim and fertility rate was 52% when 8 ± 0.5 hours in 0.8 mL/kg. The highest fertility rate was recorded in 0.6 mL/kg of dosage. Although 8 ± 0.5 hours ovulation time was recorded in 0.6 mL/kg and 0.8 mL/kg of body weight of female, their fertility rates were different.

Keywords: Fish breeding, Egg diameter, Hand stripping, GnRH, Fertility rate

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Strategies to Reduce Larval Cannibalism of *Pangasius sutchi*

W.M.W.S. Thilakarathna[1], E.D.M. Epasinghe[2], T.A.D.W. Karunaratne[2], A.M.A.N. Adikari[2], N.P.P. Liyanage[1]

[1]*Department of Animal Science, Uva Wellassa University, Badulla, Sri Lanka.*

[2]*National Aquatic Resource Research and Development Agency, Crow Island, Colombo 15, Sri Lanka.*

Ornamental fish industry is the most significance income earning approach in Sri Lankan economy. *Pangasius sutchi* (Thai pangus) is considered as the most popular ornamental fish species. In their early larval stage, they show cannibalistic behaviour which leads reduction of population. Then experiment was conducted to reduce the larval cannibalism of larvae within first 72 hours because it has been identified as the critical period of their cannibalistic behaviour. Therefore several types of feed, feeding frequencies and stocking densities were tested. We investigated the effect of two different types of feed(*Artemia* and Moina),three different feeding frequencies (3hr,4hr,5hr)and three different stocking densities(60.90.120)one square feet can hold 80 larvae and 22"×10×10glass tank can hold approximately 94 *P.sutchi* larvae. Each tank was randomly assigned to one of the treatment. At the end of the experiment numbers of survivals were calculated to determine the cannibalism rate. Five fish from each tank were sampled to measure body length. Then numbers of average body length were recorded. Data were statistically analized by using MINITAB 17 software. Significance levels were calculated to determine whether there is any relationship or not. Results showed that the feed types were not significantly ($p>0.05$) affect the survival rate and it only affected the body length. Feeding frequency was significantly ($p<0.05$) affected the survival rate and not affected the body length. And also results showed that stocking density affected the survival rate significantly ($p<0.05$) and not affected significantly for body length of larvae. Final results indicated that highest mean survival rate was recorded with 60 stocking density whereas lowest survival rate was recorded in 120.highest mean body length was recorded with the *Artemia* feeding with 3hour feeding frequency.

Keywords: Cannibalism, Feeding frequency, Stocking density, *Artemia*, *Moina*

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Development of *In-vitro* and Conventional Propagation Protocols for Two Different Endemic Species of *Aponogeton* (*Aponogeton rigidifolius and Aponogeton jacobsenii*)

W.N.V. Weerasekara[1], B.V.A.S.M. Bambaranda[2],
S.C. Jayamanne[1], S.A. Krishnarajah[2]
[1]*Department of Animal Science, Uva Wellassa University, Badulla, Sri Lanka*
[2]*Royal Botanic Gardens, Peradeniya, Sri Lanka*

This research was focused on the development of successful propagation protocols for two different endangered and threaten aquatic plant species of *A. rigidifolius* and *A. jacobsenii*. Due to lack of effective propagation methods, *Aponogeton* species indiscriminately harvested from wild and leads to extinct. To overcome the problem of species loss and inadequate supply to the local and foreign market, *in vitro* and conventional propagation protocols were developed for both species. Rhizomes, seeds and leaf explants of both species were sterilized using NaOCl and 0.1 % $HgCl_2$ and established on full strength MS medium supplemented with combination of 6-benzylaminopurine (BAP) 2, 3, 5 mg/L with or without 0.1 mg/L indole acetic acid (IAA) for initiation. For shoot multiplication 2, 3, 5 mg/L BAP were used. Rhizome cuttings and seeds of both species were planted in pots, which contain sand, sand: top soil, top soil and boggy soil with water as conventional propagation method. Experiment was arranged in Complete Randomized Design method and data were analyzed using ANOVA and Tukey's Test. The presence of growth regulators had significant effect ($p<0.05$) on shoot initiation of *A. rigidifolus* rhizome. The highest shoots per replicate (2.4) were proliferated in 2 mg/L BAP medium. Application of hormones had a significant effect on number of leaves and seedling height of seed explants of both species. Maximum number of leaves (5) and seedling height (5.8cm) in *A.rigidifolius* obtained from the treatment which supplemented both 5 mg l^{-1} BAP and 0.1 mg l^{-1} IAA while the highest leaves (3.43) and height (1.92 cm) shown in 5 BAP alone medium in *A. jacobsenii* seedlings. The highest shoots per seedling (4.2) obtained from 2 mg l^{-1} BAP contain multiplication medium in *A. rigidifolius* seedling. Conventional growth media significantly influence on the shoot development from *A. rigidifolius* rhizome cuttings, seed germination, and in other seedling growth parameters of both species. Mean number of leaves, height of seedlings, and number of roots and length of roots were high in both plants which planted in boggy soil medium. The highest shoots of *A. rigidifolius* obtained in sand medium.

Keywords: *Aponogeton rigidifolius, Aponogeton jacobsenii, in-vitro,*

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Induced breeding of Silver Dollar (*Metynnis hypsauchen*) using ovaprim

K.A.J.L. Kodisinghe and S.C. Jayamanne
Faculty of Animal Science and Export Agriculture, Uva Wellassa University of Sri Lanka

and

A.H.M.S.S.K. Abeysinghe
National Zoological Gardens, Anagarika Dharmapala Mawatha, Dehiwala, Sri Lanka

Introduction

Production of ornamental fish is a rapidly growing sector of the aquaculture industry (Tlusty, 2001). Among the ornamental fish production in Sri Lanka, exotic ornamental fishes have a significant demand in the market.Silver Dollar (*Metynnishypsauchen)* which was originated from South America is such kind of exotic ornamental fish in Sri Lanka that a higher demand has been achieved. Silver Dollar is not breeding very often in Sri Lankasince it takes a longer spawning period. To avoid that problem, the fish can be bred artificially. Among all the artificial breeding methods, induced breeding by hormone administration is the most reliable method (Yanong, *et al*., 2013). In this study attempts were made to develop induced breeding of Silver Dollar (*Metynnis hypsauchen)* in Sri Lankan environmentusing inducing hormone "Ovaprim".

Materials and method

Sexually matured and healthy Silver Dollar brooders were selected based on the external features. Eighteen pairs in same age were randomly collected and conditioned. Then Ovaprim as a single dose by intramuscular injection at a dosage of 0.2 $mlkg^{-1}$, 0.3 $mlkg^{-1}$, 0.4 $mlkg^{-1}$, 0.5 $mlkg^{-1}$ and 0.6 $mlkg^{-1}$ of body weight was administered to the brooders. Natural spawningwas also allowed without inducing by Ovaprim as a control. After the hormonal injection, the best range of Ovaprim dose to have least response time and better breeding performance of Silver Dollar was determined based on response time (hours). Relative fecundity, post mortality rate of brooders and water quality parameters in experimental tanks were also monitored.Data analysis was done by one way ANOVA and Tukey test.

Results and Discussion

The effects of different doses on the breeding performance of Silver Dollar are shown in Table 1.Salmon gonadotropin releasing hormone analogue sGnRHa (Ovaprim) successfully induced spawning in Silver Dollar (*Metynnis hypsauchen*). Five different Ovaprim doses supported the spawning activity and the breeding performance was favored by lower and middle inclusion level of Ovaprim dose in the experiment.

Ovaprim is a well-known commercial spawning aid which is mostly used in induced breeding of fish (Anonymous, 2012). It has been used in successful manner for several fish families (Hill *et al*., 2005). In the present study,all the brooders spawned, except the brooders which were injected with 0.6 ml kg^{-1} of body weight Ovaprim. Among those 6 treatments, the least response time was recorded with 0.3 ml kg^{-1} of body weight Ovaprim as 5.66 hours. The maximum response time was observed in naturally spawned pairs as 632 hours (27 days). According to the literature, 0.5 ml kg^{-1} of body weight is the standard Ovaprim dose for fish (Hill *et al*., 2005). However, in the case of Silver dollar, 0.3 ml kg^{-1} of body weight is the best dose to have the minimum response time (Table 1).

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Table 1: Breeding performance of Silver dollar induced with Ovaprim

Parameter	Dose 1 (0 ml kg^{-1} OP)	Dose 2 (0.2 ml kg^{-1} OP)	Dose 3 (0.3 ml kg^{-1} OP)	Dose 4 (0.4 ml kg^{-1} OP)	Dose 5 (0.5 ml kg^{-1} OP)	Dose 6 (0.6 ml kg^{-1} OP)	P value
RT (hrs)	632± 146.60^{a}	6.33± 0.57^{b}	5.66± 0.28^{b}	9.50± 0.50^{b}	7.00± 0.50^{b}	0.00± 0.00^{b}	0.000
RF	4.63± 1.86^{ab}	3.61± 1.32^{ab}	2.19± 1.20^{bc}	5.22± 0.30^{a}	6.43± 0.50^{a}	0.00± 0.00^{c}	0.000

[Values are presented as means ± S.D., means in each raw with different superscripts are significantly different from each other. (OP: Ovaprim; RT: Response time; RF: Relative fecundity)]

The maximum relative fecundity was observed with 0.5 ml kg^{-1} of body weight Ovaprim (Table 1). Dose range between 0.4ml kg-1 - 0.5 ml kg^{-1} of body weight could be identified as the better range to have a higher fecundity. Because of that, further studies should be followed to identify the best dosage which is occurred between 0.4 ml kg^{-1} - 0.5 ml kg^{-1} of body weight Ovaprim. Spawning has not occurred with 0.6 ml kg^{-1} of body weight Ovaprim (Table 1). It indicates that, dosage beyond 0.5 ml kg^{-1} of body weight Ovaprim might not be effective in breeding of Silver Dollar. The use of Ovaprim as a spawning aid in ornamental fish was surveyed in the United States, and they have found that some species may not be responsive to the GnRHa in Ovaprim or may require application under a different protocol (Hill *et al.*, 2005). Based on the literature and the obtained results of the present study, a comparatively medium level of Ovaprim dose (0.4ml kg^{-1}– 0.5 ml kg^{-1}) can be recommended for a higher relative fecundity.

The survival rate of brooders was 100 % after Ovaprim was injected. According to the observation, the hormone dosage range which was used for the present study might not be harmful and there was no negative effect to Silver Dollar. Achionye and Obaroh, (2012) have found that procedure of injection, quality of the hormone and degradation of water quality during holding and handling of fish affect to the post mortality of brooders. At the present study, conditioning and domesticating brooders before hormone injecting, maintaining water quality, supplying nutritious feeds, using quality hormone and reduced handlings of fish due to the single dose administration to both sexes might have affected for this decreasing of post mortality of brood fish (More *et al.*, 2010). There was no any significant difference ($P > 0.05$) in water temperature, Dissolved oxygen and pH in six different treatment tanks.

Since a successful result could be obtained through the study, following further studies and providing the facilities for practicing induced breeding of Silver Dollar using Ovaprim can be done to make Silver Dollar available to breeders and producers for mass scale production. Because, considering the relatively simple technique involved, this activity has the potential to create adequate job opportunities, increase export earnings as well as develop the ornamental fish industry in Sri Lanka.

Conclusions

Minimum spawning time in Silver Dollar can be achieved by 0.3 ml kg^{-1} of body weight and maximum relative fecundity can be obtained with 0.5 ml kg^{-1}body weight Ovaprim. From the

available references along with the present study on the induced breeding of the Silver Dollar, it was observed that better breeding performances were achieved from a comparatively lower dosage of Ovaprim.

Acknowledgement

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Development of micropropagation protocols for two aponogeton species of Sri Lanka (*Aponogeton crispus* and *Aponogeton natans*)

T.W.G.J.C Amarawansha, B.V.A.S. M. Bambaranda and S.C. Jayamanne
Faculty of Animal Science and Export Agriculture, Uva Wellassa University of Sri Lanka

and

H.M.I Herath
Royal Botanic Gardens, Peradeniya

Introduction

Sri Lanka being a tropical country contributes for a highly diversified flora and fauna. These climatic conditions have become a critical factor for the occurrence of highly diversified aquatic flora as well. *Aponogeton* is genus of aquatic plants which belongs to the family Aponogetonaceae. According to Bruggen there are four *Aponogeton* species occur in Sri Lanka (Dassanayake and Fosberg, 1987). Among these species *Aponogeton jacobsenii and A. rigidifolius* are endemic to Sri Lanka while *A. natans* and *A. crispus* are native plants (Wijesundara and Shantha Siri, 2004).They are having a high demand as an aquarium decorative plant in the export market. This study was carried out to develop a micropropagation protocol for mass production of *A. crispus* and *A. natans* and *A. jacobsenii* species.

Methodology

The study was carried out at tissue culture laboratory of Royal Botanic Gardens, Peradeniya. Mother plants were collected from different areas of Sri Lanka. Experiments were done to determine hormonal effect on shoot initiation and multiplication using rhizomes of *Aponogeton crispus* and *A. jacobsenii*; leaf and leaf stalks of *A. natans* and *A. jacobsenii* and seeds of *A. crispus* and *A. natans.* For the Sterilization of *A. crispus* and *A. jacobsenii* rhizomes were kept under running tap water for 3 hours and dipped in a fungicide for 30 minutes. Then disinfected using 20 % NaOCl (Clorox) with 2 drops of Tween twenty for 10 minutes and washed with 0.1 % $HgCl_2$ for 7 minutes. Finally rhizomes were washed 5 times thoroughly with distilled water per 5 minutes. For seeds sterilization seeds were kept under running tap water for 10 minutes, disinfected using 5 % Clorox with 2 drops of Tween twenty for 15 minutes and washed 3 times with distilled water. Three sterilization procedures were carried out for leaves and leaf stalks. Firstly leaves kept under running tap water for 1 ½ hours and dipped in fungicide (topsin) for half an hour. Then washed with 5 % of NaOCl (Clorox) for 10 minutes and washed with 0.1 % $HgCl_2$ for 3 minutes. Finally leaves washed 3 times with distilled water. Again sterilization procedure was tested by using 5 % NaOCl for 5 minutes and 0.1 % $HgCl_2$ for 2 minutes. As the final method leaves were sterilized with 2 % of NaOCl for 2 minutes 0.1 % $HgCl_2$ for 1 minute. Basal full strength MS medium supplemented with 20 mgL^{-1} of sucrose and 7 gL^{-1} of agar was used. pH was adjusted to 5.6. Different levels of BAP and IAA hormones were tested for the experiments (Figure 1, 2, 3). Cultures were maintained under controlled condition of 26 ^{0}C +/- 2 ^{0}C temperatures and white fluorescent light with 16 hour photoperiod for shoot regeneration. Ten replicates per each treatment were maintained and media without adding hormones used as the control. Experiment was arranged in factorial Complete Randomized Design (CRD). Data analyzed using ANOVA and Tukey's Test using MINITAB 17 software.

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Results and Discussion

In the study only rhizome culture of *Aponogeton crispus* and seed culture of *A. crispus* and *A. natans* were succeeded. Shoot initiation was not observed in rhizome culture of *Aponogeton jacobsenii* within six week time period. Leaf and leaf stalk culture was unsuccessful due to over sterilization. The effects of the hormone concentration on shoot regeneration of *Aponogeton crispus* had shown a significant difference ($p < 0.05$). Maximum mean number of shoot initiation was observed in culture medium T6 (Figure 1). Minimum number of shoot initiation was observed in T7 (Figure 1). Shoot regeneration was not observed in hormone free MS medium. There was a significant different between T1, T4 and T6 (Figure 1).

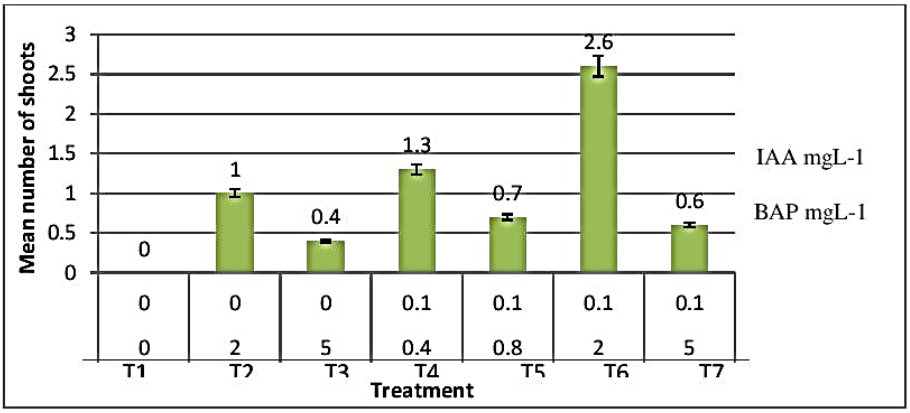

Figure 3 : Effect of hormone concentration on shoot initiation of *Aponogeton*

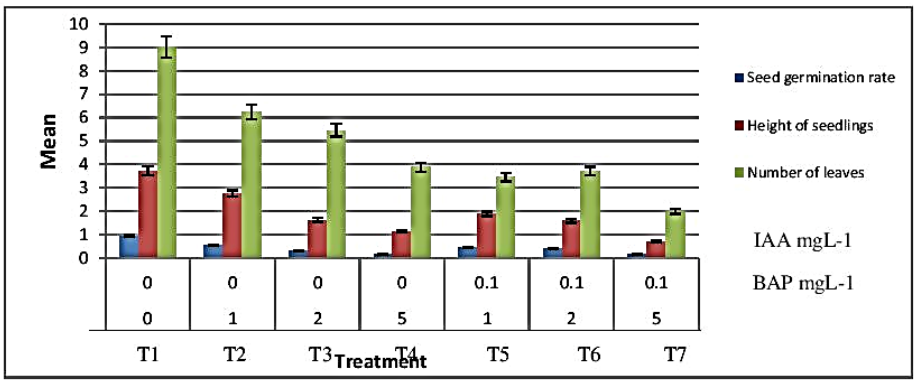

Figure 4: Effect of different hormone concentration for Seed culture of *Aponogeton natans*

Seed culture of *Aponogeton natans* and *A. crispus* were succeeded. The data analysis of *Aponogeton natans* seed culture had shown a significant difference ($p < 0.05$) in mean of seed germination rate, mean height of seedlings and mean number of leaves. Highest mean of seed germination rate was observed in hormone free MS media (T1). Minimum mean number of seed germination was observed in medium supplemented with 5 mgL^{-1} of BAP. There was a significant difference among T1, T2 and T4. The maximum mean height of seedlings and the maximum mean number of leaves were observed in hormone free MS medium followed by T2, T3, T4 and T6 (Figure 2). The minimum height of

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seedlings and the minimum mean number of leaves were observed in T7 medium which was supplemented with high concentration of BAP (5 mgL^{-1}) and IAA (0.1 mgL^{-1}). (Figure 2)

There was a significant difference in treatments for seed germination ($p < 0.05$) of *A. crispus*. The maximum seed germination was recorded in hormone free MS medium (T1). The minimum seed germination was observed in T4 medium which was supplemented with 1 mgL^{-1} of BAP and 0.1 mgL^{-1} of IAA. The maximum mean height of seedlings and the maximum mean number of leaves were observed in hormone free MS medium (T1). The minimum mean height of seedlings and the minimum mean number of leaves were observed in medium which contained 1 mgL^{-1} of BAP and 0.1 mgL^{-1} of IAA. (Figure 3)

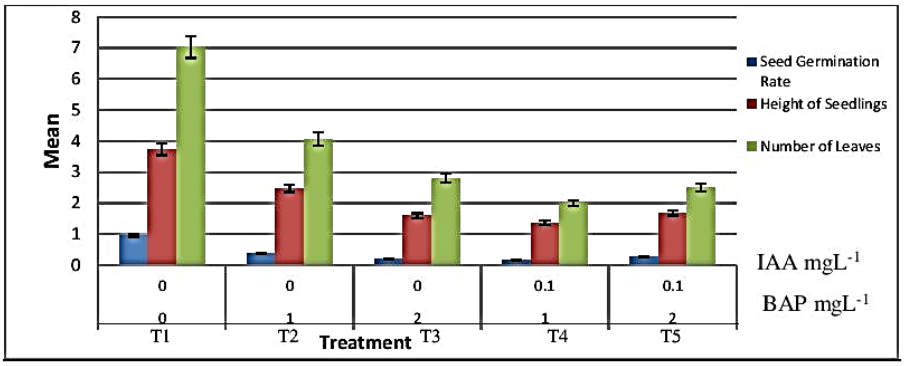

Figure 3: Effect of different hormone concentration for Seed culture of *Aponogeton crispus*

Medium supplemented with 2 and 5 mgL^{-1} of BAP were used for shoot multiplication. Data analysis of *A. crispus* and *A. natans* had shown a significant difference ($p < 0.05$) among hormone treatments. Maximum was obtained in the medium supplemented with 2 mgL^{-1} of BAP. The toxicity caused by an excess of growth regulators in the culture medium, or the extended period of time in which the culture was exposed to them, might lead to genetic, physiological and morphological changes, resulted in a reduction of the proliferation rate in vitro (Narayanaswamy, 1977). It is therefore important to evaluate their effects on plant regeneration.

Conclusion

Among selected hormone concentrations 2 mgL^{-1} of BAP and 0.1 mgL^{-1} of IAA is the most suitable combination for shoot regeneration of *A. crispus*. MS medium without hormones is more effective for seed culture of *A. crispus* and *A. natans*. Culture medium supplemented with 2 mgL^{-1} of BAP is more suitable for multiplication of seedlings of *A. natans*.

Acknowledgement

I'd like to convey my sincere gratitude to Dr. S. A. Krishnerajah, Deputy Director of Floriculture Research and Development. Also to all the staff members of Tissue culture laboratory at Royal Botanic Gardens, Peradeniya.

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Effect of growth regulators on in-vitro multiplication of *Lagenandra ovata* and *Lagenandra lancifolia*

W. M. A. Senavirathne, Mrs. B. V. A. S. M. Bambaranda and Dr.S.C.Jayamanne
Faculty of Animal Science and Export Agriculture, Uva Wellassa University of Sri Lanka

and

Dr. S. A. Krishnarajah
Royal Botanic Gardens, Peradeniya, Sri Lanka

Introduction

Sri Lanka is a country which consists with number of endemic aquatic plants. These endemic aquatic plants are having high demand in aquatic plant industry (Galapitagedra, n.d.). Due to the lack of effective propagation methods plant collectors collect plant from wild to fulfill the market demand. It leads to the depletion of natural plant stock and bio diversity. *Lagenandra* species only can observe in Sri Lanka, Southern India and Bangladesh (Dassanayake *et. al*., 2001). In Sri Lanka there are seven species and six species are considered as endemic. Red List of International Union for the Conservation of Nature in 2013, categorized five of those endemic species under the highly threatened category. Main purpose of this study is to develop a proper method for micro propagation of *Lagenandra ovata* and *Lagenandra lancifolia* to overcome inadequate supply and depletion of natural plant stock. Present study was carried out to evaluate effect of different hormone concentrations in basal media for shoot initiation and multiplication of rhizome explants,to identify the best explant of *L. lancifolia* for micro propagation and to identify the best medium for *L. ovata* seed culture.

Methodology

Present study was carried out at Royal Botanic Gardens, Peradeniya. Seven experiments were conducted in order to achieve the objectives of the study. Explants of *L. ovata* (rhizome and seeds) and *L. lancifolia* (rhizome and smaller plantlets) were sterilized using standard procedures. *L. ovata* rhizomes were placed in Ms Semi-solid media with different cytokinins such as BAP, Kinetin and TDZ with the presence of IAA. Different concentrations of BAP and Kinetin such as 0.4, 0.8, 2, 5 and 8 mgl^{-1} and 0.4, 0.8, 1.6 and 2 mgl^{-1} of TDZ were used. Grown plants of *L. ovata* were transferred in to multiplication media with 1, 2 and 3 mgl^{-1} BAP hormone concentrations. Smaller plantlets of *L. lancifolia* were placed in MS semi solid media with and without growth regulators. Different concentrations of cytokinins such as 0.4 and 0.8 mgl^{-1} of BAP and Kinetin concentrations and IAA were added to the medium. Grown Plantlets of *L. lancifolia* were transferred in to multiplication medium with 1, 2 and 3 mgl^{-1} BAP hormone levels. Survival rate of *L. lancifolia* plantlets and rhizomes were measured weekly in order to identify the best explant. The best medium for *L. ovata* seed germination was identified by placing seeds in different media such as; solid medium, semi-solid medium, liquid medium and sterilized distilled water medium. After the germination seeds were transferred in to solid or semi-solid medium for further growth.

Results and Discussion

This study shows the importance of growth regulators for the shoot initiation of *L. ovata* rhizome culture. According to the one way ANOVA, there was a significant effect ($p<0.05$) of growth

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regulators such as BAP, Kinetin and TDZ on shoot initiation. The highest mean number of shoot initiation of *L. ovata* rhizomes was observed at 0.4 mgl^{-1} Kinetin with the presence of 0.1 mgl^{-1} IAA. The second highest mean number of shoot initiation was observed at 0.8 mgl^{-1} TDZ with the presence of 0.1 mgl^{-1} IAA. According to the data lower concentrations of growth regulators stimulate shoot initiation highly. Highest shoot multiplication was observed at 2 mgl^{-1} BAP level. According to the one way ANOVA there was a significant effect of hormone treatments for the shoot multiplication ($p < 0.05$).

Table 1: Effect of different BAP hormone concentrations for the mean number of new shoot regeneration after three weeks of culture establishment

Treatment	BAP hormone concentration (mgl^{-1})	Mean number of new shoot regeneration
Control	0	0.000^{b}
T_1	1	1.000^{b}
T_2	2	2.667^{a}
T_3	3	0.667^{b}

Means that do not share a letter are significantly different

As indicate by the table there was a significant difference between treatment 2 and all other treatments. Hormone free MS media did not show any shoot initiation or multiplication. The highest seed germination of *L. ovata* was observed in sterilized distilled water medium at the second week of culturing. Low contamination possibility and low cost are main advantages of sterilized distilled water medium. There was a significant difference of seed germination between sterilized distilled water and all other treatments.

Table 2: Mean number of seed germination in different media after two weeks of culture establishment

Treatment	Media type	Mean number of seed germination
T1	Solid media	2.400^{c}
T2	Semi- Solid media	2.600^{bc}
T3	Liquid media	4.800^{b}
T4	Sterilized distilled water	8.200^{a}

Means that do not share a letter are significantly different

The best shoot initiation of *L. lancifolia* smaller plantlet culture was observed at 0.4 mgl^{-1} Kinetin with the presence of 0.1 mgl^{-1} IAA hormones.

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Table 3: Effect of different BAP hormone concentrations for mean number of new shoot regeneration of *L. lancifolia* after three weeks of culture establishment

Treatment	BAP hormone concentration (mgl-1)	Mean number of new shoot regeneration
Control	0	0.000[c]
T1	1	1.333[b]
T2	2	2.667[a]
T3	3	1.000b[c]

Means that do not share a letter are significantly different

As indicated by the above table there was a significant difference in new shoot regeneration of both treatment 1 and 2 when compare to the other treatments. The highest shoot multiplication of *L. lancifolia* was observed at 2 mgl^{-1} BAP level. Therefore treatment 2 was considered as the best treatment for new shoot regeneration of *L. lancifolia*. The survival rate of *L. lancifolia* rhizome was below 30% and survival rate of plantlets was above 80% at the fifth week of culture establishment. Therefore, smaller plantlets of *L. lancifolia* were recommended as the best explants source.

Conclusion

Hormone treatments should be used for the shoot initiation of *L. Ovata* rhizome cultures. According to which obtained 0.4 mgl^{-1} Kinetin with presence of 0.1 mgl^{-1} IAA suitable or both *L. ovata* rhizomes and *L. lancifolia* smaller plantlets culture. The maximum shoot multiplication was observed at 2 mgl^{-1} BAP level. Smaller plantlet of *L. lancifolia* is recommended as the best explants source for micropropagation based on the survival rate. Best medium for *L. ovata* seed germination is sterilized distilled water.

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A review of export trade of indigenous aquatic plants species in Sri Lanka and their conservation issues

R.D.C. Bandaranayake, B.V.A.M.S. Bambaranda and S.C. Jayamanne
Faculty of Animal Science and Export Agriculture, Uva Wellassa University of Sri Lanka

and

R. D. A. M. G. Niyarepola
Biodiversity, Cultural and national Heritage Protection Division of Sri Lanka Customs, Customs House, No 40, Main Street, Colombo 11

Introduction

Aquatic plants are adapted to aquatic environments and are required special adaptations for living submerged in water or at the water's surface. In addition to various ecological and industrial values, most of aquatic plants are having ornamental value. Due to the ornamental value of the aquatic plants, they have a huge demand and are exported from Sri Lanka. Along with ornamental fish industry, aquatic plants are introduced and exported as a simultaneous industry. Present study was intended to analyze and evaluate the trade of ornamental aquatic plants in Sri Lanka with a particular focus on indigenous species. The objectives of the study are determine the exported species and their quantities, the actual foreign exchange earnings, identify the conservation issues related to indigenous species, identify the trends to occur irregularities in exportation procedure and propose suitable.

Materials and Methods

Exported aquatic plants species data and their quantities were extracted from the Customs Goods Declaration Forms (CusDec) submitted by the ornamental aquatic plants exporters to the Air Cargo Terminal in Katunayake under the Department of Sri Lanka Customs. The Customs Goods Declaration Forms submitted during the period of one year from 1st March 2013 to 28th February 2014 were analyzed. A questionnaire was also used to gather information regarding the conservation issues through ornamental aquatic plants exporters, Custom officers at frontier and local villagers.

Results and Discussion

During the one year period from 1st March 2013 to 28th February in 2014, a total of 218 species of aquatic plants has been exported to 43 countries from Sri Lanka. Among the total, 176 species were indigenous, 1 species was endemic. When considering the total quantities of exported indigenous aquatic plants during the one year period, the most common species exported was the *Dracaena sanderiana white* (168185 individuals) and *Lobelia cardinalis "small leaf"*(4 individuals) was the species exported in least quantities. During the one year study period, 1504531 individuals of aquatic plants and 2047620 all types of live plants have been exported from Sri Lanka. When considering the proportions of species exported during one year period, the endemics consist of 0.04% (685individuals) and other indigenous species consisted of 80.91%(1217353individuals) among all other aquatic plants. The proportion of indigenous aquatic plants species consisted of 59.45% and endemics consisted of 0.03% among exported all types of live plants from Sri Lanka. And the proportion of exported aquatic plants to all live plants is 73.47% from Sri Lanka during my study period.

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The foreign exchange earned from ornamental aquatic plant industry has shown a considerable level of earnings. The all individual export prices of species ranged from US $ 0.14 to US $ 12.99. Among all exported indigenous aquatic plant species, *Echinodorus grisebachiibleheri* has earned highest amount (SL Rs. 84,051,603.55) while *Dracaena sanderiana* baskets have brought in the least earning (SL Rs. 199.06) during the concerned time period.

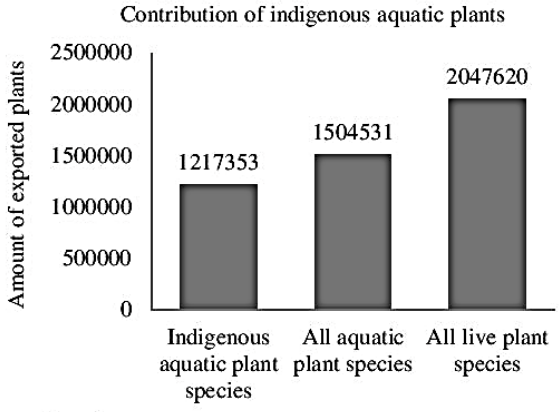

Figure5: Indigenous aquatic plants contribution to the all live plants exported

Total income generated from the ornamental aquatic plant trade during one year period was SL Rs.546,950,172.67 (US $ 813,735.45).When considering the earnings, contribution of indigenous aquatic plant species was SL Rs. 447,667,856.28 (US $ 3,373,279.00) and it was 80.16% from total export of ornamental plants. The earnings obtained from the endemic aquatic plant species was SL Rs. 499,075.86 and contribution is 0.091% for the aquatic plant industry. The contribution of the endemic plants to the all live plants exported is negligible (0.089%). Finally, the contribution of the ornamental aquatic plants for all exported live plants is 97.94%.

There were only 13 exporters who actually engaged in exportation of live ornamental aquatic plants during my study period. From that, all exporters were identified as indigenous aquatic plant exporters who are occationally export endemic species based on the foreign demand. The exporters are not extracting plants from the wild and contribution of nurseries production of plants for export is 100%.

Since, in spite of all precautionary measures are taken by Biodiversity, Cultural and National Heritage Protection division of Sri Lanka Customs, maximum advantage of loopholes in regulations is taken by smugglers through false declarations and misleading terms. According to the approximate calculations of previous offences committed by exporters who were found guilty in the Customs detections (As per the information found in Casefiles), SriLanka Customs had detained ("Kekatiya") *Aponogeton crispus* (US $ 730,325) and *Cryptocoryne species* (US $ 1800) on the suspicion of violation of regulations under the Forest Ordinance and Custom Ordinance which were attempted to export through BIA, Katunayake without having permission. Those smuggled aquatic plants have collected from several tanks in Puttalum and Kurunegala districts.

The sustainability of the ornamental aquatic plants industry and the conservation of endemic and indigenous aquatic plants can be mandated and committed by enforcement of existing laws and legislations. The greatest thing is long run economical gains obtained through the protection of ecosystems than any short term economic return earned from smuggling, over exploitation like undesirable activities. If the involvement of the government authorities is in a sufficient condition,

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the due revenues from the trade can be increased. But the legal status behind the export of endemic plants species hampers their development and therefore, investments are worthless until legal status are cleared and positively regulated. Adequate culture techniques are not practiced by the exporters to boost the industry with new technology and conservation of the endangered species. The major factors which are responsible for the depletion of water plants from the natural environment are deforestation, constructions, sand and gem mining, bad practices of fish harvesting methods, agricultural and industrial wastes, over exploitation and invasive species. Therefore the government should involve for collaborate all those parties for a sustainable trade of aquatic plants in Sri Lanka and awareness should be created among all stake holders of ornamental aquatic plants industry including officers at frontiers, exporters, farmers, students, conservationists and all related agencies.

Conclusion

During the period of one year from 1st March 2013 to 28th February 2014, 176 aquatic plants species were indigenous out of all 218 species identified. The quantity of exported indigenous aquatic plants species has shown a considerable proportion to exported aquatic plants species, 80.91%. It is noteworthy to highlight that 73.47% of the entire export quantity of annual live plants trade consist of aquatic plants species. The calculated actual foreign exchange earnings from exported indigenous aquatic plants species was 80.16%. The main causative factors should be minimized to address conservation issues such as constructions, deforestation, sand and gem mining, industrial and agricultural wastes and invasive species. Based on the gathered information from the exporters, there are no exporters who practice wild collection of endemic species. The irregularities at the exportation procedure are taken place basically due to false declarations and misleading terms. Therefore, the laws and regulations should be enforced and monitored to avoid misconducts and corruptions.

Acknowledgement

Firstly I would like to convey my greatest gratitude to Head, Department of Animal Science Dr. S.C. Jayamanne and to my internal supervisors, Mrs. B. V. A. S. M. Bambaranda and Dr. S. C. Jayamanne. Then special thanks all the staff members of the Aquatic Resources Technology degree program. And I convey my special gratitude to my external supervisor Mr. R.D.A.M.G. Niyarepola, Deputy Director of Customs who strengthened me with his advice and guidelines during my research period. Also, I want to thank Dr. W. M. H. K. Wijenayake, for his kind guidance and support during my research.

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Effects of pH on Egg Hatchability, Survival Rate and Growth Rate of Yolk Sac Larvae of Goldfish (*Carassius auratus*)

K.Y. Gunasinghe, N.P.P. Liyanage, D.P.N.de Silva
Uva Wellassa University, Badulla, Sri Lanka

and

M. Epasinghe
National Aquatic Resources Research and Development Agency, Crow Island, Mattakkuliya, Sri Lanka

Introduction

Ornamental fish trade is a global industry of significant economic importance. For a developing country like Sri Lanka if managed sustainably, fresh water ornamental fish trade can generate employment opportunities as well as foreign exchange (BOBP, 2000). Goldfish (*Carassius auratus*) is a well known freshwater ornamental fish, which is among the most popular freshwater fishes throughout the world.

Water quality parameters have profound effect on fish's biological and physiological factors. For successful fish culture proper management of water quality parameters are required as they are crucial for larval survival and growth (Zaniboni-Filho, *et al.*, 2008: Smartt and Bundell, 1996: Lloyd and Jordan, 1964 cited in Gao, *et al.*, 2011). pH, potential hydrogen ion concentration is such an important water quality parameter in aquaculture.

Fresh water ornamental fish culturists in Sri Lanka uses water from different water sources such as tap water, underground water and surface water sources like rivers, streams, reservoirs, tanks. Due to different climatologic and geographic factors, pH value of above fresh water sources may differ from each other (Silva and Manuweera, 2004). Most of the fresh water sources in Sri Lanka are having pH range of 5.4 -9.0 (Silva, 2004: Kotagama, *et al.*, 1989).

The main objective of this study is to find out the effects of water pH on egg hatchability, survival rate and growth rate of yolk sac larvae of goldfish and to identify the most suitable water pH range for goldfish culture.

Methodology

The experiment was carried out at the ornamental fish unit in Inland Aquatic Resources and Aquaculture Division at the National Aquatic Resources Research and Development Agency (NARA), Mattakkuliya. The tap water of the hatchery with the pH 7.5 was used to prepare the pH series. Five pH solutions were prepared having values of 5.5 ± 0.1, 6.5 ± 0.1, 7.5 ± 0.1, 8.5 ± 0.1, 9.5 ± 0.1, pH 7.5 served as the control pH level. pH was measured using the pH meter, pH 211 Microprocessor with the precision of ± 0.01 pH (HANNA instruments). Alkalinity and water hardness was measured using titrimetric methods. Tuning of the pH was done with sulfuric acid and Sodium hydroxide throughout the experiment.

Completely Randomized Block design was used as the experimental design. Fifteen 500 mL beakers were used for the experiment. Each beaker was filled with 400 mL of

respective solution. Three replicates were used for each pH level. Goldfish brood stock was bred using 2:1 male to female ratio and 40 goldfish eggs were placed in each beaker. Mild aeration was supplied through air stones continuously to ensure a sufficient Dissolved Oxygen level. Beakers were covered with glass lids to minimize the water evaporation.

Hatchability was measured in proportion to the number of yolk sac larvae present compared to the total number of eggs placed in the beaker. Survival rate was measured in proportion to the number of larvae present at the end of the experiment to the number of yolk sac larvae present at the beginning of the experiment. Growth rate was measured in relation to the yolk sac absorption rate. Yolk sac absorption rate was measured as the percentage change in a yolk sac volume over time.

$$\text{Yolk sac absorption rate} = \frac{\text{(Initial yolk sac volume-Yolk sac volume at 3}^{rd}\text{ date)}}{\text{Initial yolk sac volume}} \times 100$$

Data obtained regarding hatchability, survival rate and yolk sac absorption were analyzed using the n Krukal-Wallis test, the non parametric version of one way ANOVA, at the 0.05% significance level with MINITAB 14. As sample size is small and the data is not normally distributed, Kruskal-Wallis test was used to analyze the data.

Results and Discussion

Alkalinity during the period of study was 24.6 mg / l and water hardness was 24 mg / l. No significant difference ($p < 0.05$) observed in the hatchability, survival rate and growth rate with varying pH from 5.5 – 9.5. Mean values for egg hatchability varied between 87.50 % – 97.50 %, mean values for survival rate varied between 85.82 % – 98.29 % and mean values for yolk sac absorption varied from 78.59 % to 96.42 % at the tested pH range.

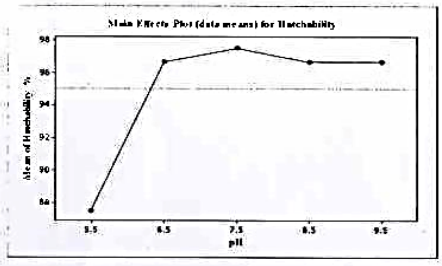

Figure 1: Main effect plot for hatchability

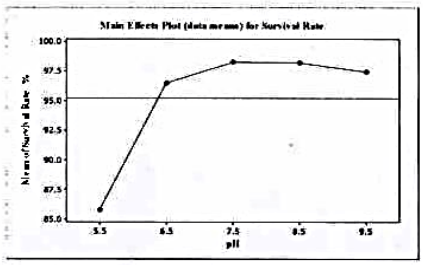

Figure 2: Main effects plot for survival rate

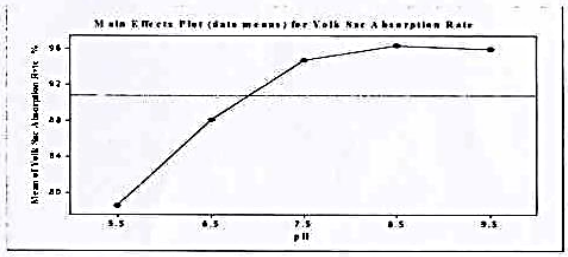

Figure 3: Main effect plot for yolk sac absorption rate

The lowest mean values (numerically) for hatchability, survival rate and growth rate were observed in pH 5.5 compared to the other pH levels (Figure 1, 2, 3). At other pH levels there is no variance between treatments, which proves that near neutral and slight alkalinity levels are more suitable for egg hatchability, survival and growth rate of the yolk sac larvae of goldfish.

A similar finding on reduction of egg hatchability of fathead minnow at pH 5.9 was observed by Mount, 1973. Highest egg hatchability of goldfish was observed in the control pH of 7.5, similarly Gao, *et al.*, 2011 reported that the highest egg hatching rate of Far Eastern catfish was observed in pH 7.

Lowest survival of this study was observed in the pH 5.5 and highest was observed in pH 7.5. Similarly survival rate of *Procilodus lineatus* larvae at pH 4.8 – 5.9 is recorded about 70% - 80 % while it is about 90 % at pH 8.7 – 9.2 (Zaniboni-Filho, *et al.*, 2008).

Yolk sac absorption rate (which is proportionate to the growth rate) of goldfish yolk sac larvae was lowest at the pH of 5.5 and increased with the increasing pH. Lopes *et al.*, 2001 as cited in Copatti, *et al.*,2011 report that exposure to low pH 5.5 -6.0 reduced length and weight of silver catfish larvae compared to those maintained at pH 8.0 -8.5.

Though pH 5.5 is showing lowest values for the test parameters compared to the other pH values, it is also showing comparably acceptable level of hatchability, survival and growth rate. Therefore pH 5.5 also could be used for goldfish fish culture .Thus it is possible to state that 5.5 - 9.5 pH range is suitable for goldfish eggs and yolk sac larvae, while to obtain best performances it is suitable to have neutral to slightly alkaline pH range. Copatti, *et al.*, 2011 also had stated the same phenomenon while Wurts and Durborrow, 1992 stated that 6.5 -9.0 pH range is desired for fish production.

Conclusion

It can be concluded that the water having neutral or slightly alkaline pH is more suitable for culturing yolk-sac larvae of Gold fish. However, the performance at low pH value also is in the acceptable range and can also be used in situations where neutral or slightly alkaline water is not available.

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Fisheries

A Review on Export Trade of Freshwater Ornamental Fish Species in Sri Lanka

T.D.N.K.S. Rathnamurthi, P.C.B. Dias, J.M.D.R. Jayawardana, J.D.M. Senevirathne and N.P.P. Liyanage

Department of Animal Science, Uva Wellassa University, Badulla, Sri Lanka

Freshwater Ornamental Fish industry of Sri Lanka has developed rapidly during the last few decades due to high export demand. Industry sustains with culture of exotic species rather than a wild collection of ornamental fish including endemics. Hence, a review on the present status of the export industry of Freshwater Ornamental Fish and identification of the existing gaps are important for further development in the industry. Secondary information on exporting levels, species and countries were collected from Sri Lanka Customs. Further, 32 registered exporters were identified using NAQDA registry and pretested questionnaire was used to collect information on knowledge of exporters, productivity and export details. Results revealed that majority of export fish varieties were Guppy (87%) followed by Platy (3.3%), Molly (2.2%), Tetra (2%), Zebrafish (1.7%) and Barb (0.9%). According to the results, demand for the exporting fish is changed with the quarters of the year and majority of the species (Guppy, Platy, Molly, Tetra) have high demand in 1st quarter. Demand for Zebra fish and Barb fish has high demand in 4th and 2nd quarter of the year respectively. Results of the survey indicated that 80% of companies target only the export market rather than local trade. Majority (55%) of the exporters depended on local farmers to fulfill their requirement of export market. This vast export demand still cannot be achieved due to the communication barriers (67%) among farmers and exporters. The major constrains were identified as difficulties of recognise the actual market demand (87%), lack of adequate knowledge and technical approach regarding disease control (73%) and water quality management (87%). "Ceylon Fish Guide" a user-friendly android tool was developed to enhance the knowledge and communication of farmers and exporters. Therefore, improving the ornamental fish industry with novel technologies is important to compete with global market.

Keywords: Freshwater ornamental fish, Sri Lanka custom, Exporters, Mobile application, Lanka Fish

Identification of Factors affecting to the Blue Swimming Crab (*Portunus pelagicus*) Harvest in Eastern Province, Sri Lanka

A.A.F.S. Infaas, N.P.P. Liyanage*, I.U. Wickramaratne, J.M.D.R. Jayawardana, P.C.B. Dias

Department of Animal science, Uva Wellassa University, Badulla, Sri Lanka

The blue swimming crab; *Portunus pelagicus* is a tropical marine crustacean species, having higher demands in local and global crab market during last few decades. But, there are limited studies on present harvest of blue swimming crab industry in Sri Lanka. Hence this study was conducted to investigate the current status of Blue swimming crab fishery and factors affecting on the daily harvest of Blue swimming crab in the Eastern Province, Sri Lanka. Stratified and Random Sampling techniques were used to select the target and by catch fisheries from Ampara, Batticaloa and Trincomalee districts. Data associated with harvesting methods and practices of Blue swimming crabs were collected from 372 fishermen and 23 sellers using pre tested structured questionnaire. Collected data were statistically analyzed using Minitab 17 software and MS Excel. Multiple Linear Regression model was fitted to determine the main factors affected on the daily Blue swimming crab harvest. Descriptive statistical analysis suggested that majority of the fishermen in the Eastern Province used Gill net (94.7%), while less percentage of fishermen used Cast net (2.9%) and Trap net (2.4%). It was found that, in average 4.5 kg of daily harvest was obtained and average price of blue Swimming crab was Rs 271.69 per kg. Furthermore, results of Regression analysis revealed that there is a significant relationship in daily Blue swimming crab harvest with mesh size, length of net, depth of net and number of net pieces ($p<0.001$). Study concluded that improving these factors would increase the Blue swimming crab harvest in Eastern Province of Sri Lanka and necessary attention needs to be given at policy making in future.

Keywords: Blue swimming crab, Harvest, Eastern province, Regression

Preliminary Study of the Elasmobranch Fishery in Valaichchenai, Sri Lanka

T.N. Dharmakeerthi[1], I.U. Wickramaratne[1*], S.C. Jayamanne[1], D. Fernando[2], A.V. Tanna[2] and R.M.K. Bown[2]

[1]Department of Animal Science, Uva Wellassa University, Badulla, Sri Lanka
[2] Blue Resources Trust, Colombo, Sri Lanka

Sharks and rays are included within the sub class Elasmobranchii. Indiscriminate fishing techniques have resulted in the progressive depletion of their populations globally. In Sri Lanka, these fisheries are driven by demand for shark fins, mobulid gill plates, their fresh meat and dried fish. This study collected information on shark and ray landings to provide information for sustainable management practices. A questionnaire survey was conducted with 140 fishers and biological parameters (length, weight and maturity data) were collected from 123 shark specimens and 129 ray specimens in Valaichchenai (7°55.58', 81° 31.80'), in the Eastern Province of Sri Lanka. Results showed a female biased sex ratio for sharks. 11.76% of them were observed to be pregnant. From the male sharks, 16% were immature. For the rays, 40% were immature, comprising of 67% of females of which 3.44% were pregnant. The most abundant species with growth coefficients and condition factors were *Carcharhinus brevipinna* (1.25, 1.09), *Carcharhinus limbatus* (2.80, 0.83), *Carcharhinus amboinensis* (2.36, 1.17), *Mobula japonica* (1.62, 1.47) and *Neotrygon kuhlii* (1.86, 1.98) respectively. All species showed a negative allometric growth, except *Carcharhinus limbatus* and most of the species have shown condition factor greater than one. The questionnaire revealed that fishers were aged between 18 to 68 years (mean=37.55±11.23) and 64% of fishers stated that their fishing area is as far North as Jaffna, with offshore ranging from 10-700 km. There was no significant difference between attitudes on the awareness of rules and regulations with fishers of varying age groups, but propensity of crossing boundaries showed a significant difference ($p<0.05$) with age group. The results showed that some endangered species such as *Sphyrna lewini* and also vulnerable species such as, *Mobula tarapacana* were being caught and immature males & pregnant females were landed. These results indicate the need of proper implementation of management plans for sustainable utilization of these resources. Thus, conducting awareness programs, declaring restricted areas (nursery grounds) and optimum length at first capture are important for sustainable utilization of fishery resources.

Keywords: Elasmobranch, Growth factor, Condition factor, Maturity, Gill plates

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Computer Based Fisheries Management Tool to Sustain Consumption of Marine Food Fish Species in Sri Lanka

P.C.B. Dias[1], J.D.M. Senevirathna[1], N.P.P. Liyanage[1], H.M.U.M. Herath[2]

[1]*Department of Animal Science, Uva Wellassa University, Badulla 90000, Sri Lanka*
[2]*Department of Computer Science and Technology, Uva wellassa University, Badulla 90000, Sri Lanka*

Diverse fish stocks in the Indian Ocean consider as overfished, resulting in large-scale fishery termination will appear in the near future. Prior to taking purchasing decision, identification of the fish species is significant to take the decision correctly. Hence the aim of this study is to provide a tool for fish identification and make attitudinal changes of the consumers to take right purchasing decision for those overfished marine fish species. A questionnaire survey was carried out to collect fish consumption data in Sri Lanka using a random population. Questionnaire survey further investigated the best method to inform the consumer with above information. Selected fish stock status was recorded with the available colour code from Indian Ocean Tuna Commission database. Conservation status was recorded from the International Union for Conservation of Nature database and ranked according to a colour code. Combining stock status and conservation status colour codes, a different scale with five colour sustainable rating was generated. A traffic light method that displays consumer advice to avoid (red), suit (green) or think (yellow) was developed using above sustainable rating. Morphological identification keys for each species under four dominant fisheries impacted marine food fish groups were developed. Lanka fish website was developed to update the consumer using single page application module. Out of 22 selected fish species, three species were to avoid, five species for suit and 14 species need to think prior to purchase. All selected 22 species were clearly separated and identified with distinct characters from generated keys. According to the survey, maximum respondents have selected website (38%) as an effective method to aware the consumers while the minimum was selected radio (4%). The developed website can be used in the actual purchasing moment and it clearly demonstrates the consumer advice for each species in a user-friendly manner. Fisheries resources are highly diverse and depended on responsible management decisions and practices for their sustainable development. Many fish stocks are in a stage of serious decline with overfishing. Hence the future of fish stocks unable to judge by any authority. It should be done by reducing the demand for those unsustainable fish stocks. Practically the developed website, Lanka fish will act as the foremost fisheries management tool in Sri Lanka to aware local and international consumers. Further, it will play an important role in securing future of the selected fish sustainably in the Indian Ocean.

Keywords: Consumers, Fishery, Indian Ocean, Lanka fish, Sustainability.

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Identification of Factors Affecting the Survival of Lobster Exports Industry in Sri Lanka with Special Reference to Spiny Lobster

L.P.S. Chamodika[1], S.C. Jayamanne[1], T.G.A. Duminda[2]
[1]*Department of Animal Science, Uva Wellassa University, Badulla, Sri Lanka.*
[2]*Biodiversity Protection Unit, Sri Lanka Customs, Colombo 01, Sri Lanka*

At present there are five main species of Spiny Lobsters exported from Sri Lanka. There are controversial findings regarding lobster resource and it is required to know the current status of the lobster resource in Sri Lankan oceanic waters. Thereby the status of lobster fishery and exports industry as well as the factors affecting the survival of lobster exports industry in Sri Lanka are required to be identified. The present study was carried out to fulfill this requirement. Questionnaires and direct interview methods were used to obtain the relevant information from the exporters, lobster fishermen, lobster purchasing centers and collectors. Lobster export data and catch data were analyzed by using MS Excel. Information related to legal aspects and other stock assessment projects related to lobsters were obtained from Ministry of Fisheries and NARA. Currently, *Panulirus longipes* is the mostly exported lobster species and it accounts for 30.4% of total lobster exportation. *Panulirus ornatus* is nearly overexploited. *Panulirus polyphagus* has completely vanished from Sri Lanka. *Panulirus ornatus* fetch the highest price in the export market (US$ 70/Rs. 8200 per Kilogram). Highest lobster production and export quantity as well as the highest export value were earned in 2013. Availability of the lobsters in the ocean around Sri Lanka, laws and regulations, political influence, Scuba divers & other recreational divers, problems faced by the lobster fishermen, problems faced by the exporters, illegal activities done by fishermen, collectors and exporters are the factors affecting the survival of lobster exports industry in Sri Lanka which were identified from the present study. Some of these factors affect positively on the survival of lobster exports industry while other factors affect negatively on the survival of this industry. Relevant authorities should take steps to protect this lobster resource while providing opportunities to the fishermen, exporters and local consumers to use the resource in a sustainable manner.

Keywords: Lobster export industry, Lobster production, Stock assessment

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An Investigation of the Economic Impact on Fishing Communities in Mannar District Caused by Illegal Fishing by Indian Trawlers in Sri Lankan Waters

B.M.K. Sosai, I.U. Wickramaratne, S.C. Jayamanne,
Department of Animal Science, Uva Wellassa University, Badulla, Sri Lanka,

Mannar district is located in the Northwestern Sri Lanka (8° 52′ 0″ N, 80° 4′ 0″ E). Thalaimannar, Pesalai, Vankalaipaadu, Erukkalampiddy, Pallimunai, Panankaddikoddil, Thalvupadu in Mananr District were selected for the study. Primary data were collected through a questionnaire survey and direct interviews with fishing community leaders, officials of department of fisheries, fishing agents and traders. Information on fishing season (charts), monthly income, the relative impact of Indian trawlers on village fishing activity, direct and indirect losses to the ancillary service sectors in each village, the quantities of fish and fish species caught by Indian trawlers and the number of Indian trawlers and their annual production were obtained. Secondary data was gathered through research papers, publications and internet. Gathered data were analysed with three approaches i.e. Approach A: Direct losses due to Indian trawlers harvesting Mannar's marine resources, (estimated daily and annual direct losses were Rs.54.4 million and Rs.6955.2 million, respectively) Approach B: Indirect loss due to Mannar fishermen by not being able to harvest Mannar's marine resources (estimated annual indirect losses were Rs.425.63 million), Approach C: Direct losses due to the destruction of fishing gears (Rs. 2, 56, 18,750), Approach D: Direct and indirect losses for ancillary service sector (Rs.24, 59,400 and Rs.24, 59,400 respectively). Data were analyzed using MS Excel 2010. Indian trawlers fish in the northern Palk Bay and south of Gulf of Mannarall year round, while they trawl Pesalai, Vankalaipadu, Erukkalampiddy and Pallimunai in northern coast of Mannar from May to October. Further, Panankaddu koddil and Thalvupadu, located in Southern Mannar were trawled from November to April. Mechanized trawling has been banned by Tamil Nadu State Government for 45 days a year, therefore illegal trawl fishing stops in between March to April (about 45 days). In this study it was found that Thalaimannar (with idela location for fishing), Peasalai and Vankalaipaadu villages were highly affected. Vankaalaipaadu fishery activities mainly depend on gill net. It was found gill net fishing activity was affected by trawler activity. Five other villages faced less loss due to the operation of trawlers, because fishery activities carried out only for six months using variety of fishing gears.

Keywords: Mannar district, Indian Trawlers, Coastal fishery, Gill net, Economic Impacts.

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An Investigation on Total Catch, Catch Composition, Catch Quality Variation Based on Different Effort Levels in Multiday Boats in Kalutara District

A.W.K. Fernando[1], N.D.P. Gunawardane[2], I.U. Wickramarathna[1], S.C. Jayamanne[1]
[1]*Department of Animal Science, Uva Wellassa University, Badulla, Sri Lanka.*
[2]*Department of Fisheries and Aquatic Resources, Colombo 10, Sri Lanka.*

Deep sea fisheries commenced in late 1980s and introduction of Multiday boats with modern technologies (GPS, SSB radio, Freezer unit, Fish detecting sonar) and synthetic nets increased the pelagic fish production. The multi-day boats in operation today are of several types, varying according to their length and the degree of sophistication. Those vessels use several types of fishing gears based on their preference and also fishing duration also differ with those boats. Fishermen have their own selections on those variables according to their knowledge, experience to maximize their catch with good quality by applying minimum effort.This study was carried out to identify the deep sea fishery trends and optimum efficiency levels in Kalutara fishery district using landing statistics (Catch) and fishing inputs (effort) and to give recommendation on management of Kalutara fishing fleet. In this study, total catch per fishing trip and species wise catches taken as output data and gear type, fishing trip duration, boat length, facility level, no. of crew and boat capacity are taken as input data. Parallel organoleptic survey of fish catch was conducted to measure the quality level of fish. The study found that only the gear type is significantly affecting total catch per trip and other five factors (Boat length, Boat capacity, No. of crew, Trip duration, and Facility level) do not affect the total catch per trip. Three types of fishing gear including longline, gillnet and ring net and combination of gears was used basically and the catch composition of the single species catch is not significantly affected by gear type. Longline, gillnet and ring net when taken individually, significantly affects the species catch variation. The fish quality is significantly affected by total catch, trip duration, and boat capacity while not significantly affected by gear type and facility level. So according to the study it can be recommend that gear combination (better to use Longline cum Gill net) is the most suitable fishing method as it gives high fish catch (2427 236) with medium quality (1.8571 0.1650) fish and more emphasis should be given on fish quality improvement in Beruwala fishery harbor.

Keywords: Deep sea fishery, Multiday fishing vessels, Catch, Fishing effort, Fish quality, Fisheries management

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Evaluation of the attitude and awareness of the international resolution on responsible fishing: a case study on the multiday fishermen of Matara

K.L.N. Dilini, I.U. Wickramaratne and N.P.P. Liyanage
Faculty of Animal Science and Export Agriculture, Uva Wellassa University of Sri Lanka

and

N.D.P. Gunawardane
Department of Fisheries and Aquatic Resources Development, New Secretariat Building, Maligawatta ,Colombo 1

Introduction

Sri Lanka is an island, situated in the Indian Ocean between 6 – 10^0 N latitude and 80 – 82^0 E longitudes. This island has approximately 1700 km long coastline and sovereign power for the 21,500 km^2 territorial sea and an Exclusive Economic zone (EEZ) of 517,000 km^2 (MFAR, 2013). Therefore fisheries industry significantly contributes to the food security and the foreign exchange earnings of Sri Lanka. This IUU fishing is a serious threat to the sustainability of fisheries in both national jurisdictions and high seas. Therefore regional resolutions are implemented by the Indian Ocean Tuna Commission (IOTC) to reduce these IUU fishing activities. Although there are laws and regulations, many problems in the fisheries sector are caused due to lack of awareness of fishermen regarding these implemented national and international laws. Therefore identification of awareness of fishermen on these laws and regulations are very important before the implementation of awareness programs. This study was done with the objectives of investigating international resolutions which highly impact to Sri Lankan fisheries sector, investigate responses of fishermen on international resolutions, identify and suggest procedures which can improve the awareness and behaviors of fishermen on international resolutions.

Keywords: Illegal Unreported Unregulated (IUU) fishing, Indian Ocean Tuna Commission (IOTC), International Resolutions

Methodology

Matara fisheries district was selected as the research area. The sample for the case study was selected from multiday boat owners, crew members, skippers and other service providers of Matara fisheries district through the Stratified random sampling. The sample size was determined using "Moving average method". Data was collected from both primary and secondary sources. Primary data was collected from selected sample, through the questionnaire and interviews. The questionnaire was prepared using international resolutions which developed by the IOTC. Both open ended questions and closed ended questions were included in the questionnaire. Secondary data was collected from sources of Department of Fisheries and Aquatic Resources and IOTC web site. Collected data was analyzed using "Likert method" (Likert, 1932) and one way ANOVA (Analysis of Variance) at 95% significant interval. "Minitab 16" software was used for analyzing all the collected data.

Results and Discussion

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The sample size was selected as 105. According to the finalized results of the study, total mean of awareness and attitude regarding these international resolutions is 3.38 ± 1.58. It means that the level of awareness and attitude of fishermen of Matara fisheries district on these international resolutions are medium. The statements used for the questionnaire have derived from the IOTC resolutions (IOTC, 2013). The current awareness of stakeholders on these international resolutions is helped to keep the Sri Lankan fishermen under the international resolutions. It helps to enhance the acceptance for Sri Lankan fish and fish products in the international market. Not only that but also the awareness on some resolutions are directly influenced on the management of fishery resources.

The community has a high level of knowledge ($3.67 \leq$ Mean Likert scale ≥ 5.00) on the statements of importance of registration of fishing vessel, importance of having a flag in the fishing vessel, importance to mark vessels according to the regulations (Resolution 01/02 relating to control of fishing activities), importance of establishing a vessel monitoring program (Resolution 06/03), idea about prohibition of bottom trawling and crossing sea boundaries without proper permission, requirement of permission from the department for landing harvest at another country or for exchanging harvest with the foreign vessels at sea (Resolution 12/05 on establishing a program for transshipment by large scale fishing vessels), prohibition of catching endangered shark species and sea turtles (Resolution 12/09 on the conservation of Thresher sharks and Resolution 12/04 on the conservation of marine turtles) and preference of carrying equipment in the vessel which was used for catching sea birds and sea turtles. The registration of fishing vessel and vessel marking according to the regulations are already in place in the national regulations (1980). Therefore all of them have to comply with the registration of fishing vessel and marking them according to the regulations for having other subsidies and insurance.

The awareness was medium ($2.34 \leq$ Mean Likert scale ≥ 3.66) on the statements of importance of maintaining a log book on board (Resolution 01/02), the requirement of providing information about harvest to the Department of Fisheries, willingness to support the government officers, agree to carry a department officer as an observer when they request, importance to inform navigation path for the department or harbor (Resolution 05/03 and Resolution 10/11). According to the attitude of some stakeholders, it is difficult to carry a department officer as an observer due to the limitation of space in the vessel and several other difficulties. The idea of some skippers was important to maintain a log book to have an idea in future regarding places and time of high densities of fish. It was considered as an additional trouble for their hard occupation by others. According to the responses of stakeholders, there are some people who unable to keep records on this log book due to inability of writing.

The overall awareness was very low ($1.00 \leq$ Mean Likert scale ≥ 2.33) on the statements of international trade barriers which are occurred to Sri Lankan fisheries sector due to the ignorance of international resolutions, prohibition of large scale driftnets on the high seas in the IOTC area (Resolution 12/12), closed area (Resolution 12/13). With the high sea fishing operation license, printed material including the statements regarding the Resolution 12/12 has received by the boat owners. Therefore regarding the prohibition of large scale driftnets on the high seas, there was awareness among some people specially with the boat owners and skippers. But even the response of these people was not agreed with the idea. According to them, 2.5 km length gill nets are not enough to recover their fuel cost. The awareness of fishermen was very low regarding the closed area (Co-ordinates 0^0 - 10^0 North, 40^0 - 60^0 East in the Indian Ocean during February month) for fishing (Resolution 12/13 for the conservation and management of Tropical Tunas stocks in the IOTC area of competence). Therefore the overall response for a closed area was seriously disagreed. But some of the stakeholders believe it is necessary to have a closed area for the sustainability of fishery resources.

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Regarding six statements, there was a significant difference of the responses according to the types of stakeholders. The identified major reasons for this significant difference are difference of the participation level for the awareness programs and different attitudes among types of stakeholders. Compared to the crew members, the awareness of boat owners and skippers were high. The reason for this was identified as the high level of participation for the awareness programs while others are engaging in fishing activities. The awareness of other service providers was very low. Because they just consider on their occupation. It is better to use a media such as newspapers, television and mostly the radio which is much closer to them. Other than using the mass media for the awareness programs, it is better to display posters regarding these resolutions in the harbor premises, maintain a continuous dialogue between the stakeholders and the government. It is identified the necessity to improve their knowledge and literacy on new devices such as electronic means of communication.

The overall knowledge of fishermen of Beruwala is relatively in positive level (3.61± 1.28) about the international resolutions (Madhushani, *et al*., 2013). But knowledge level of fishermen of Matara fisheries district regarding international resolutions is medium. Therefore the level of implementing awareness programs should be different from Beruwala to Matara. The required level of awareness programs is high for the Matara fisheries district than for the Beruwala. Although there was awareness regarding some resolutions in both Beruwala and Matara, they do not act according to them. Their negative attitude regarding these resolutions is the reason for this. Therefore while improving awareness regarding international resolutions, developing positive attitudes is very important. It is necessary to improve the common knowledge of stakeholders regarding the international resolutions and importance of these resolutions.

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A comparative study on the effectiveness of gillnet and longline fishing methods used by multi-day fishermen in Matara fisheries district

M.I. Jathunga, I.U. Wickramaratne and N.P.P. Liyanage
Faculty of Animal Science and Export Agriculture, Uva Wellassa University of Sri Lanka

and

N.D.P. Gunawardane
Departments of Fisheries and Aquatic Resources, New Secretariat Building, Maligawatta, Colombo 1

Introduction

The fisheries sector of Sri Lanka is a primary source of animal protein production. According to the high rate of population growth in Sri Lanka, fish food demand is increasing. To fulfill this increasing demand, there should be an effective fishing method for high rate of exploitation and exploited resources should be high quality and high value for the better utilization. In the late 1980s, Sri Lankan state introduced multiday offshore fishing vessels for the development of Sri Lankan offshore fisheries (Kariyawasam, 2010). The gillnet fishery and the longline fishery is the common fishing methods used in the deep sea fishing in Sri Lanka. According to the DFAR statistics in 2013, Matara fisheries district is one of the districts which provide high fish production to the nation. The gillnet fishery is most commonly used fishing method in multiday boats fishermen in Matara fisheries district and they do not engage in longline fishery very much. The identification of the suitable fishing methods is important to increase production level, quality of the production and income of the multiday fishermen. Therefore the present study is focused on comparison of the effectiveness of gillnet fishing and longline fishing methods as a deep sea fishing method used by multiday fishermen in Matara district.

Materials and Methodology

The data were collected from multiday fishing boats in "Dondra" fisheries harbor from 1st of May to 14th of June 2014. The sample size was determined by "Moving average method" and the total landings and fishing methods of 66 multiday boats were collected accordingly. Catch and effort data, income of the fishermen and quality of the landing were collected using prepared data sheets. The catch and effort data collection sheet was consisted of data regarding the duration of the fishing, the fishing techniques (gear) used in the trip, total catch per day, the species composition of the catch in number and/ or weight, gear information (length of net, mesh size, number of hooks per long line, soaking time,) vessel information (storage facilities, hauling technique, length of boats). The income data collection sheet was consisted of species composition, total weight of each fish species and price of the fish in particular day. Organoleptic survey has been done in order to determine the quality of the fish yield of each boat. According to the organoleptic evaluation, nature of the fish skin, nature of the gill, eye appearance and consistency of flesh were evaluated. The quality of the fish has been evaluated by scoring them according to the level of quality. Then mean of the score of the quality parameter was calculated to determine quality of the harvest in each multi-day boat. The collected data have been analyzed by using "Microsoft excel-2010" and compared with "One-way ANOVA table" by using "Minitab 16" software.

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Results and Discussion

According to the study, there were 3 types of main fishing methods which were used by multi-day fishermen in Matara fisheries district. They are, gillnet, longline and combination of gillnet and longline fishing methods. There were 39.4% multiday fishing boats which used only gill net, 22.7% multiday fishing boats which used only long line and 37.8% fishing boats which used a combination of gillnet and long line. Mainly tuna and tuna like species were targeted in the study. The total catches of the different fishing gears were taken as weight of harvest per boat day. According to the results, the mean catch per boat day of the gill net, long line and combination of the longline and gill net were 133.7 kg, 94.2 kg, and 165.1 kg respectively. Therefore the multiday boats which used combination of gillnet and longline fishing method gained significantly higher yield than that of gillnet and longline fishing methods. The lower mean catch per boat day was gained by the longline fishing method.

When considering main fish species which were caught by each fishing gear, the mean catches per boat day of Skipjack tuna (*Katsuwonus pelamis*) were 62.11 kg, and 64.76 kg respectively for gill net, and combination of the gill net and longline. In Matara fisheries district there were no multiday fishermen who used longline fishing method to catch skipjack tuna. The mean catches per boat day for yellow fin tuna (*Thunnus albacares*) were 7.05 kg, 79.39 kg and 70.56 kg respectively for gillnet, longline and combination of gillnet and long line. Similarly the mean catches per boat day of frigate tuna (*Auxis thazard)* were 12.29 kg, and 70.56 kg in gillnet, and combination of gillnet and longline respectively. There was no frigate tuna catch in long line fishery. According to this result, mainly long line fishing gear was used to harvest yellow fin tuna. The skipjack tuna and frigate tuna were harvested by using gillnet fishing method.

When considering income of the multiday fishermen, the mean of the total income of multi-day fishermen who harvested fish using gill net, longline and combination of gillnet and longline is Rs 300,577.00, Rs 1,251,567.00 and Rs 1,068,474.00, respectively. The highest income was gained by the multi-day fishermen who used longline fishing method and the lowest income was gained by fishermen who used gillnet fishing method, among the three fishing methods.

According to the organoleptic survey data, the quality of the fish in gill net, long line and combination of gill net and long line fishing methods were 1.99 ± 0.41, 2.32 ± 0.31 and 2.04 ± 0.39, respectively. The quality of the fish was high in fish which were harvested by longline and quality was low in fish which were harvested by gillnet.

In the ANOVA test, there was not significant different between gear categories and the total catch per boat day ($P>0.05$). But, there was a significant different between gear categories and catch per boat day of tuna and tuna like species ($P<0.05$). Similarly, there were significant differences between gear categories and income of the fishermen and also gear categories and quality of fish ($P<0.05$). According to these result, it shows gear categories are not significantly affect on the total catches per boat day but it significantly affect for the catches of tuna and tuna like species, income of the fishermen and quality of fish.

According to the above results, the gillnet fishing method has recorded, high catch, low income and low quality fish and long line fishing method has recorded low catch, high income and high quality fish while combination of gillnet and long line fishing method has recorded high catch, medium income and medium quality fish.

But the ANOVA result showed total catch per boat day was not significantly affected by fishing gear categories. Therefore, though they have similar amount of fish harvest, multi-day boat fishermen who used longline fishing method has had high income and high quality fish than other two types of fishing methods. The analysis of catch composition of tuna and tuna like species showed that long

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line fishing method is much more species selective fishing gear than other two types of fishing methods. It is used to catch only target fish species which having high commercial value. And also, the amount of fish discarded by the longline is less than that of gillnet due to harvest of high quality fish in longline fishing method. The reason is that the fish remain alive for much longer period when hooked than when gilled (Santos*et al.*, 2002). Because of that reason, the quality of the fish that harvested by longline is higher than gillnet fishing method. Because of their high quality, the value of the fish increases and fishermen obtained higher income with the longline fishing method.

Conclusion

When considering all these aspects, it can be suggested that the longline fishing method is an effective fishing method for multi-day fishermen in deep sea fishing at Matara fisheries district comparatively. And the longline fishing method can be used to harvest other targeted fish species by changing bait types and hook size.

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Balancing the benefits of protein content and the risks of trace metal toxicity exposure from Skipjack tuna (*Katsuwonus pelamis*) consumption in Sri Lanka

A.S. Mahaliyana, N.P.P. Liyanage and S.C. Jayamanne
Faculty of Animal Science and Export Agriculture, Uva Wellassa University of Sri Lanka

and

B.K.K.K. Jinadasa
Institute of Post-Harvest Technology, National Aquatic Resources Research and Development Agency, Colombo15, Sri Lanka

Introduction

Fish is considered as an excellent source of protein that can provide immense health benefits to human being. Protein is the major nutrient in fish consumption and it is highly digestible and consist all the essential amino acids. However, recent claims that marine fish are contaminated with trace metals exceeding the recommended maximum allowable limits have raised concerns among consumers regarding fish consumption. This may lead to rejection of marine fish both by local and export markets (Liyanage, 2009) as fish contaminated with toxic trace metal can lead to acute and chronic effects in human being. In the present study, protein content and major toxic trace metal concentrations in skipjack tuna (*Katsuwonus pelamis*) which is a major commercial marine fish species were studied with the aim of assessing benefits and risks in consumption of skipjack tuna in Sri Lanka.

Materials and Methods

Samples of skipjack tuna fish (n = 44) were collected to represent all fish landing site areas around Sri Lanka during April-July, 2014. Concentrations of toxic trace metals Hg, Cd, Pb and As were analysed individually for all the samples while the protein content analysis was carried out for composite samples that were prepared based on gender and standard length of each fish. Crude protein content was analysed according to 928.08, AOAC 2000 standard method. Crude protein content was determined using UDK 132 (VELP Scientifica, Usmate, Italy) semi-automated Kjeltec system. All composite samples were analysed in triplicates. Hg, Cd, Pb and As trace metal concentrations were analysed by Atomic Absorption Spectrophotometer (AAS; Varian240 FS, Varian Inc., Australia) following the standard method in AOAC 1998. All analyses were strictly adhered with quality control procedures. Protein content of skipjack tuna was assessed in terms of benefits with reference to its Recommended Dietary Allowance (RDA) value whereas the toxicity of each trace metal was assessed based on the stipulated Provisional Tolerable Weekly Intake (PTWI) with the Probable Weekly Intake (PWI) values. Average consumption of skipjack tuna flesh in Sri Lanka was considered as 2.8 g/person/day (MFARD, 2013) and the average body weight of a Sri Lankan adult person was assumed as 55 kg. In addition, resulted mean toxic trace metal concentrations were compared with the established maximum allowable limits for toxic trace metals in Sri Lanka and European Union standards for skipjack tuna.

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Results and Discussion

In order to determine the recovery percentage in crude protein analysis, spiked samples with $(NH4)_2SO_4$ were used and the recovery values were maintained within the acceptable range of 90-110%. The method of trace metal analysis was evaluated for its suitability in terms of their respective Limit Of Detection (LOD) and recovery levels using spiked samples and certified quality control materials. Calculated recovery values for all the trace metals were within the expected recovery range of 80%-120%.

The mean standard length of the analysed skipjack tuna fish was 47.4±3.9 cm and the range was 36-56 cm whereas the mean total weight was 2.2±0.5 kg and it had a variation of 1.1 - 4.2 kg. Among the analysed specimens 24 were males and 20 were females.

Table 1: Protein content (%) of the flesh of skipjack tuna and other major tuna species*

	Skipjack tuna [a]	Yellowfin tuna[b]	Bigeye tuna[b]
Crude protein	24.13±2.01	23.52±0.61	23.72±0.16

* Data are expressed as mean±SD on a fresh weight basis

[a] The present study

[b] Peng *et al.*, 2013

As per the results obtained, skipjack tuna is a good source of protein (Table 1). The resulted percentage value for protein content of skipjack tuna was compared with the values recorded by Peng *et al.*, 2013 for other major commercially important tuna species; yellowfin and bigeye tuna (Table 1). This shows that skipjack tuna is similar in terms of protein content; the major targeted nutrient in fish, with yellowfin and bigeye tuna. The resulted percentage value in this study for crude protein content in skipjack tuna slightly differs with the results of certain previous studies. This could be due to the variation of protein content in fish according to the seasonal changes as described by Clucas and Ward, 1996. Although skipjack tuna is a rich source of protein, the obtained value for the contribution for RDA value was lower (1.2%). The major reason to gain this lower value is the average skipjack tuna consumption in Sri Lanka is still a lower value (2.8 g/person/day).

Table 2: Provisional Tolerable Weekly Intake (PTWI) and Probable Weekly Intake (PWI) values of Hg, Cd, Pb and As

Toxic trace metal	PTWI* (mg/kg of body weight)	Provisional Tolerable Weekly Intake (mg)	Probable Weekly Intake (mg)
Hg	0.005	0.275	0.0025
Cd	0.007	0.385	0.0003
Pb	0.025	1.375	0.0001
As	0.015	0.825	0.0180

* WHO/FAO Joint Expert Committee on Food Additives and Contaminants

According to the results of the present study, all the recorded mean values for toxic trace metal concentrations were lower (0.13±0.06 Hg, 0.02±0.01 Cd, 0.01±0.01 Pb and 0.92±1.12 As in mg/kg). All the recorded mean values were well below the established maximum allowable limits for toxic trace metals in Sri Lanka and European Union standards in terms of seafood safety. The resulting of lower concentrations for all the toxic trace metals could be due to the reason that skipjack tuna is a

short lived animal which has a less potential for bioaccumulation. All the calculated PWI values were well below the estimated PTWI values (Table 2). This indicates that skipjack tuna does not contain a health risk on human due to trace metal toxicity.

In recent past several researchers have claimed that most of the major and popular marine food fish such as yellowfin tuna, bigeye tuna, sward and certain marlin fish have an increased risk of trace metal toxicity (Kojadinovic *et al*., 2007; Jinadasa *et al*., 2014). In addition, the market values of these major marine food fish are very high with compare to skipjack tuna (MFARD, 2014). As per the results of this study, skipjack tuna is a good source of protein which does not contain any health risk due to trace metal toxicity and can be accessed by consumers for a cheaper price.

Conclusion

Skipjack tuna is a good protein source as same as the majorly attracted other tuna species such as yellowfin and bigeye tuna by the fish consumers. Skipjack tuna does not pose any health risk due to trace metal toxicity by Hg, Cd, Pb and As.

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A study on shelf life of export oriented fresh chilled Yellowfin tuna loins in relation to histamine content

T.R. Kapugama Arachchige, S.C. Jayamanne
Faculty of Animal Science and Export Agriculture, Uva Wellassa University of Sri Lanka

and

K. Amarasinghe
SGS Lanka (Pvt) Limited, Colombo, Sri Lanka

Introduction

Sri Lanka has become a leading country which produces Yellowfin tuna (*Thunnus albacores*) and other large pelagic species in the Indian Ocean. (Indian Ocean Tuna Commission, 2011). To meet export market, maximum histamine content of the product should not exceed 50 ppm (Food and Drug Administration, 1998). Seafood processing factories guarantee a shelf life of 14 days for the product fresh chilled Yellowfin tuna loin, even though shelf life of different Yellowfin tuna loin batches is varied. Shelf life can be exceeded or not exceeded 14 days in different batches. These batches represent Yellowfin tuna received from different fishing harbors in different proportions. According to the fishing harbor environmental factors and practices followed by fishermen can be varied. There is evident that depending on the nature of the environment, different proportions of decarboxylase positive bacteria would be present in water and external fish tissue, and therefore the level of histamine and other toxigenic amines formed in fish tissue would not be uniform (Yoshinga and Frank, 1982). This research is to identify whether these fishing harbors have an effect on the shelf life of fresh chilled Yellowfin tuna loin in relation to histamine content.

Methodology

The study was carried out at SGS Lanka (Pvt) Limited, Colombo 02. The sample collection and background study of fresh chilled Yellowfin tuna loin exportation was done at Global Seafoods (Pvt) Limited. Three repeated experimental trials on histamine analysis of Yellowfin tuna loin samples were conducted during a time period of 42 days. Storage time period of each set of samples for an experimental trial was 14 days. Selected fishing harbors were Beruwala, Tangalle, Chilaw, and Trincomalee. Yellowfin tuna loins of Grade A and B were selected from each fishing harbor. All collected samples had an on-broad freezing time period, which was varied between 18 - 22 days. Labeled and vacuum packed samples were stored at 0 ^{0}C, in the fresh chilled condition. Histamine analysis was carried out from the time period of zero day of storage to 14 days of storage. Histamine was analysed using flurometric method according to the AOAC official methods of analysis. Data collected from the three experimental trials were analysed using Minitab 14 statistical software. Descriptive statistics of means, Standard deviation, two-way ANOVA and one way ANOVA with tukey's pairwise comparison was applied in analysing the results. A significance level of 5 % was used.

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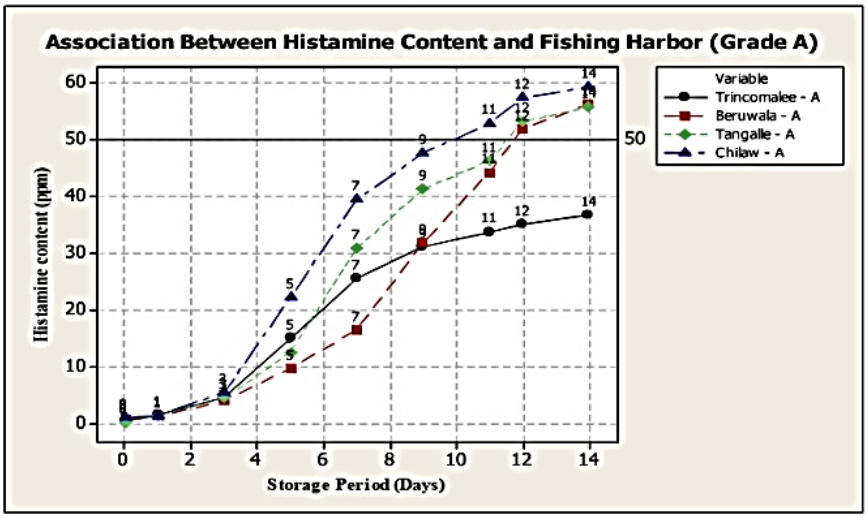
Result and Discussion

Histamine content was increased with storage time period in each and every sample. The increment pattern of Yellowfin tuna loins received from four selected fishing harbors of Grade B did not show any significant difference (P>0.005). It was concluded that there was an effect from fishing harbor on average histamine content of Yellowfin tuna loins within fish grade A (P<0.005). Further analysis of one way ANOVA with tukey's pairwise comparison revealed that Trincomalee fishing harbor had the least contribution for histamine formation.

Figure 01: Association between the average histamine content of Yellowfin tuna loins and



fishing harbor (Grade A – Histamine analysis experiment 1)

According to Figure 01 the shelf life of Yellowfin tuna was varied between 10 to 14 days. Figure 2 revealed a Shelf life of 9 to 10 days in Yellowfin tuna loin samples of Grade B. Higher bacterial loads seemed to be associated with the formation of higher amines in storage (Koutosomanis *et al*., 1999). Thus this study reveals due to high microbial contamination in Grade B, a significant difference cannot be identified in the pattern of histamine formation of the loin samples received from four different fishing harbors. Furthermore due to high microbial contamination histamine formation was happened at an alarming rate. Fish grading A with the least microbial contamination had shown a difference in histamine formation according to the fishing harbor. It was proven Yellowfin tuna loins received from Trincomalee fishing harbor had the best shelf life in relation to the histamine content with in the "A" grade fish. The reason behind this is histamine formation is highly affected with the amount of microflora and the microbial load that could contaminate a fish would not uniform from place to place, due to factors like environmental conditions, post harvest practices followed by fishermen and fish catching methods.

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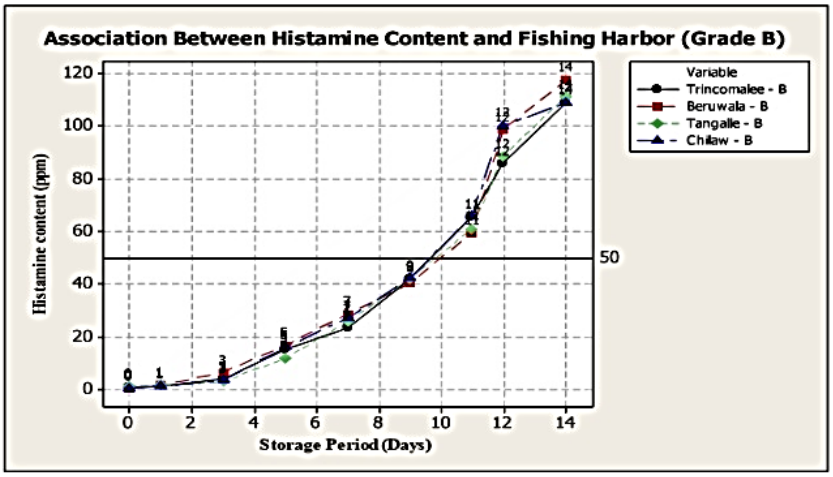

Figure 02: Association between average histamine content of Yellowfin tuna loins and fishing harbor (Grade B - Histamine analysis experiment 1)

Conclusions

Shelf life of fresh chilled Yellowfin tuna loins, in relation to histamine content was highly dependent on the fish grading rather than the conditions of the fishery harbor.

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Study on Level of Histamine in Yellowfin Tuna (*Thunnus Albacares*) in Relation to Body Size, Seasonal Variations and Spatial Variations

T.C.H. Piyadasa, S.C. Jayamanne
Uva Wellassa University of Badulla, Sri Lanka

and

M.P. Weththasinghe
Ceylon Fresh Seafood (Pvt) Ltd

Introduction

Sri Lanka has a 1500 km costal line and 23000 km^2 exclusive economic zones and the country has been engaged in fishery activity for a long time. Tuna is one of most imported fishery product in Sri Lanka and the annual production is around 80,000 metric tons (Fisheries year book, 2008). The European Union is the highest importer of tuna from Sri Lanka followed by Japan and United Kingdom of America respectively. Yellow fin tuna (*Thunnus albacares*) is the species mainly exported as fresh fish products from Sri Lanka. Private sector plays a dominant role in the processing, marketing and distribution of fish for local consumption and exports.

Histamine is a naturally occurring substance in mammalian physiology and when it is released in large amounts causes allergic and other reactions (Cavanah and Casale,1993). Histamine exerts its effects by binding to receptors on cellular membranes in the respiratory, cardiovascular, gastrointestinal and haematological/ immunological systems and the skin. Hence, the tuna with higher histamine levels are rejected in the export market.

When consider landing sites, good hygienic practices on board fishing vessels, especially during landing and processing, is important to minimize contamination with non-indigenous histamine producing bacterial species. Good hygiene at processing and preparation stages further along the supply chain is also important for the histamine development. So far, research has not been conducted in Sri Lanka regarding this issue and the present study aims to identify the factors inducing elevation of histamine levels in Tuna fish and improving the conditions to reduce histamine levels in Tuna.

Methodology

Research was conducted at the Ceylon Fresh Seafood (Pvt) Ltd fish quality checking laboratory. Negombo, Dondra, Tangalle and Trincomalee were selected as four landing sites as they contribute to high yields of tuna in Sri Lanka. 1200 samples were taken from yellowfin tuna fish at the receiving point after measuring weight and standard length. Core texture sampling was used to take a sample of 15 g from just below the pectoral fin and from the tail part. Samples were collected in to polythene bags and stored in ice. Collected samples were sent to the lab inside a cooler container and the histamine level of the samples was checked. Samples collected from four landing sites also represented two seasons. May to September is major tuna season in eastern costal area and November to April is the major tuna fish season in western costal area.

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Results and Discussion

The results revealed that the histamine levels in tuna caught from four sites are significant ($P<0.05$). Further analysis showed that histamine levels in tuna from Trincomalee and Tangalle are not significantly different ($P>0.05$). The same results were obtained for Dondra and Negombo. Mean histamine level of the Trincomalee and Tangalle were 7.327 and 7.797) respectively while the mean histamine level of Negombo and Dondra were 1.293 and 1.620 respectively.

Histamine affect because of time/temperature combination. When fish are caught, their temperature belongs to the water temperature at that time in the sea. In tropics the temperatures are greater than 18 °C while tuna in temperate countries are found in waters as cold as 10 °C (Brill, 1994). The fish caught from waters with high temperature has higher histamine levels.

On- board practices and sea food processing practices also affects histamine levels. Delay in refrigeration of fish also can elevate the histamine levels of tuna.

According to the results no significant correlation observed either between weight and histamine level of the fish or standard length and histamine level ($p >0.05$). The level of histamine correlated significantly with the season ($P<0.05$). The histamine level in May to September season (7.762) was higher than that of November to April season (1.852).

Around Sri Lanka, the ocean current is driven from the Bay of Bengal to the Arabian Sea during the North – East monsoon and from the Arabian Sea to the Bay of Bengal during the South – West monsoon. During the North – East monsoon, the East Indian Coastal Current (EICC) travels down the East coast impelled by the monsoon winds and fed by the rivers along the West coast. During the South – West monsoon, The West Indian Coastal Current (WICC) travels down the West Coast (Anonymous, 2004). Northern part fishermen normally prefer May to September season and western part of fishermen prefer November to April fishing season. The warmth of the currents during these periods may cause elevation or reduction of the histamine levels in tuna.

Conclusion

It can be concluded that the histamine levels of yellow fin tuna has a significant relationship with spatial variation and fishing season. However, there is no significant effect of size on the histamine level of the fish.

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Establishment of Community Based Fish Factory Through Green Supply Chain Management Approaches

A.D.Wijenayake
Uva Wellassa University, Badulla, Sri Lanka

Deepa Gamage
Industrial Development Board, Galle Road, Katubedda

and

S.C.Jayamanne
Uva Wellassa University, Badulla, Sri Lanka

Introduction

Post harvest loss is one of the main problems in Sri Lankan fish industry. According to Ministry of Fisheries and Aquatic Resources there is a 30% of post harvest loss in Sri Lankan marine fish industry. This may be due to lack of facilities and lack of knowledge of the fishermen. Under the greening concept the main idea is to increase the resource utilization by maximizing the output and reduce the environment impact. Therefore, by applying the greening concept the post harvest losses can be reduced and the environment effect could be minimized and maximum gain could be obtained from the existing resources. Establishment of a community based fish processing factory through green supply chain management approaches is tested here as an option to minimize the post harvest losses in Sri Lankan fish industry.

Methodology

As secondary data; type and quantity of fish production in each district, import quantity of the fishery products were collected from the data base of Ministry of Fisheries and Aquatic Resources (MoFAR), Ceylon Fisheries and Harbour Cooperation (CFHC) and customs reports.

As primary data; supply chain of the fish, Fishing gear, storing condition on boat, average experience in fishing, temperature after unloading, time period of fishing and total fish catch were collected by using structural interview method. The raw material flow and the material balance of the fish canning factory also were identified to get an idea about the type and the amount of waste and the environmental impact of those wastes. Then possible solutions were to minimize those effects under the green supply chain management approaches was established.

After identification of supply chain; regression model was designed to identify the factors affecting the fish quality. Fish quality was considered as the dependent variable because if the fish quality is high there may be fewer post harvest losses. Storing condition on boat, average experience in fishing, temperature after unloading, time period of fishing and total fish catch were considered as independent variables. Negombo, Beruwala, Dondra, Trincomalee and Kalpitiya harbours were selected by stratified sampling method, having highest number of multi-day boats. Those harbours were visited to collect fifty samples (ten samples from each harbour), as primary data and to get detail information on fishing methods and post harvest losses.

Then a proper site was selected and type of the fish was selected and assumed that the production will be 1500 cans per day. All other calculations were done according to this

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assumption and the feasibility study was carried out finally to find out whether the project is feasible to be implemented.

Results and discussion

The first two stakeholders (fishermen and commission agent) were analyzed by developing a regression model.

Correlation Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	P
		B	Std. Error	Beta		
1	(Constant)	100.003	8.011		12.483	.000
	Fishing gear	-3.128	1.415	-.113	-2.211	.032
	Storing	-2.531	1.248	-.087	-2.029	.049
	Temperature	-3.389	.706	-.386	-4.798	.000
	Experience	1.530	.489	.203	3.131	.003
	Time Period	-.946	.202	-.349	-4.670	.000
	Total fish	-.004	.002	-.135	-1.804	.078

Dependent Variable: fish quality

According to the result fishing gear, storing condition in the boat, average experience in fishing, temperature after unloading, time period of fishing, are the factors which are significantly affect the fish quality ($P<0.05$).

According to the collected data, identified what will the best under greening concept. If the fish quality is higher than 75% considered that those fish are very good and can be use in processing. From collected data found out the average of the "Total fish catch, Time period of fishing and average fishing experience" and find out the highest frequency of "Fishing gear and storing method in the boat" and when considering temperature after unloading, it is obviously to have less than 4^0C, if not histamine formation will be high.

According to collected data identified that average fishing experience is about seven years. When experience is high they know how to catch the fish by avoiding damages and also how to store the fish with minimum damages. When consider about the time period of fishing, identified that 13 days are the best time period of fishing. So there will not be excess fish and there may be fewer damages to fish caught early. The best quantity of fish is estimated as 2700 kg. Pole and line method found to be the best fishing method. When considering fish storing method it is better to have racks so that there will not be excess fish and there may be fewer damages to early caught fish.

Then fish processors were evaluated by identifying and quantifying raw material flow to gain the knowledge on the amount of inputs and outputs from each step. Environment impacts from each step were found out and possible solutions were suggested.

According to the collected data Matara was selected as the best location for the factory having the highest fish production in Sri Lanka. Skip jack tuna (Balaya) was selected as the best species for processing. Canning industry was selected as the processing method by looking at the quantity of fish products imported. Proper factory layout was designed to minimize the waste and all necessary steps were taken to minimize the environment effect and finally to have safe and quality products to consumers. Finally feasibility of the project was studied under the greening concept. The Return On Investment (ROI) of the project is 83.42%. It indicates that the project is highly feasible to be implemented.

Conclusions

Establishment of a community based fish canning factory under green supply chain management approaches is a highly feasible project. According to the profitability statement the return on investment was 83.42% .indicating that the project is highly feasible. However, it is not possible to achieve 100% performance at the start. Therefore, it is proposed to achieve 60% performance in the first year, 80% in the second year and finally 100% performance in the third year. So the feasibility of the project is in first year is 50.05% and the second year is 66.73% and in the third year 83.42%. The figures indicate that the project is highly feasible.

Fish quality is taken as the main factor which is affecting to the greening of supply chain. That means if the quality of the fish is high there will be less waste generation and less environment impact and also can use the existing resources efficiently. So the factors; Fishing gear, Storing condition in the boat, Average experience in fishing, Temperature after unloading, Time period of fishing and Total fish catch were identified to be affecting the fish quality.

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Food Science and Product Development

Identification of the Critical Control Points (CCPs) of a Commercially Established Pasteurized Milk Factory in Colombo

H.D.P. Ransinghe[1], R. Joseph[2], E.K.G.P.U. Dharmarathna[3], M.K. Ranasinghe[1] and E.D.N.S. Abeyrathne[1]

[1]*Department of Animal Science, Uva Wellassa University, Badulla, Sri Lanka*
[2]*Kotmale Dairy Products (Pvt) Ltd, No.20, Sri Sumana Mawatha, New Town, Mulleriywa, Sri Lanka*
[3]*Department of Export Agriculture, Uva Wellassa University, Badulla, Sri Lanka*

HACCP is a systematic method of identifying, evaluating and controlling all possible hazards associated with a food chain. Implementation of HACCP system has become a necessity for dairy processors to assure the safety and quality of their products. This study was designed to identify CCPs in pasteurized vanilla milk processing line in a commercially established pasteurized milk plant. Preliminary study was carried out to familiarize with the production process while identifying the sample collecting points as raw milk receiving, mixing tank, filling unit and storage. Samples were collected from raw ingredients receiving to the final product. Collected samples were analyzed for physical, chemical and biological hazards. To determine biological hazards, total plate count (TPC), Coliform and yeast and mould tests were done. Adulteration tests for chemical hazards and visual observation for physical hazards were done. According to analysis, physical contaminants were present in raw milk samples. However, no chemical contaminants were detected. Microbiological hazard analysis revealed that TPC and coliform count were high in raw milk samples from bowser. TPC counts of raw milk samples from different milk collecting centers were 7.39±0.31, 7.43±0.27, 7.37±0.31, 7.01±0.20 and 7.40±0.26 log cfu ml^{-1} respectively while Coliform counts were 5.27±0.48, 5.18±0.55, 5.19±0.31, 5.32±0.37 and 5.23±0.42 log cfu ml^{-1}, respectively. All samples collected before pasteurization were positive for coliform. Post pasteurization contamination was observed in few batches while samples collected after pasteurization were positive for coliform. Post pasteurization contamination was not observed in the rest of the batches. Therefore, receiving of raw milk and the storage tanks of pasteurized milk were identified as the CCPs in the production process. Monitoring and controlling the identified CCPs are really essential to ensure the safety of the final product for the consumers.

Keywords: HACCP, Coliform, Pasteurization, Total plate count

Determine the Effect of Functional Properties on Chicken Patty Incorporated with Salt Extracted Bioactive Compounds from *Pterygoplichthys pardalis* (Scavenger Fish)

K.S.M. Dissanayake, T.K. Ediriweera and E.D.N.S. Abeyrathne

Department of Animal Science, Uva Wellassa University, Badulla, Sri Lanka

Pterygoplichthys pardalis is a tropical and invasive fresh water fish. Based on literature, the extracted compounds from this fish consist of anti-oxidative, antimicrobial and Fe^{2+} chelating activities. Hence, the objective of this study was to determine the effect of these functional properties on chicken patty, incorporated with salt extracted bioactive compounds from *Pterygoplichthys pardalis*. Female fish were collected from a local reservoir and slaughtered in the field. Gonads (excluding GI tract and mucus) were separated within 3 hours and stored at 4°C. Separated parts were followed for extraction of proteins with distilled water (1:4) and then 10% (w/v) NaCl solution (1:4) and lyophilized. Extracted protein samples were incorporated to the preparation of chicken patty (Chicken meat, Salt, Spices) with 0, 0.5, 1, 1.5 and 2% (w/w) levels. Then TBARS assay, DPPH assay, Fe^{2+} chelating activity and Total plate count were done for the product for Day 0, 2, 4, 7 and 14. According to TBARS and DPPH assay 2% (w/v) incorporation level gave the highest antioxidant activity and Fe^{2+} chelating activity ($p<0.05$). Microbial counts of meat patty with 2% (w/v) incorporation level was suitable for 7 days compared with the control ($p<0.05$). As conclusion, 2% (w/v) incorporation level of salt extraction from *P. pardalis* can be used as a natural antioxidant, antimicrobial and metal chelating agent in chicken patty. However further studies needed to check for the maximum level of incorporation.

Keywords: TBARS, Bioactive compounds, Meat patty, Total plate count

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Effect of Inulin as a Fat Replacer on Quality Traits of Chicken Sausages

G.G.N. Jayarathna[1], I.P.A.U.N.K. Illippangama[1], S. Anand Kumar[2], D.C. Mudannayake[1] and D.D. Jayasena[1]

[1]*Department of Animal Science, Uva Wellassa University of Sri Lanka, Badulla, Sri Lanka*
[2]*Department of Animal Science, University of Jaffna, Kilinochchi, Sri Lanka*

Inulin is a non-digestible carbohydrate which can act as a fat replacer in various foods. Garlic bulbs are known as a rich source of inulin. This study was conducted to review the effect of replacing vegetable oil with garlic inulin on the quality traits of chicken sausages. Inulin powder was prepared using garlic bulbs by hot water extraction, vaccum evaporation and spray drying. Chicken sausages were prepared using lean chicken meat with varying percentages (1%, 2% and 3%) (w/w) of garlic inulin or commercial inulin gradually replacing vegetable oil. Control was prepared using 3% (w/w) vegetable oil with no inulin. Physicochemical and sensory properties, microbial quality and TBARS value of prepared sausages were analyzed over a one-month under frozen storage. Sausages with 2% garlic inulin showed higher overall acceptability compared to all other samples ($p<0.05$). Ash, moisture and protein contents of the sausages were increased with the increasing level of inulin while, fat content was reduced from 13.67% to 4.47% ($p<0.05$) in 3% inulin incorporated product. Inulin incorporated sausages had lower lightness (L*) values than the control ($p<0.05$). Water holding capacity was not significantly ($p>0.05$) different among the samples. Cooking loss of inulin added samples were lower than the control ($p<0.05$). During storage L* value, pH, water holding capacity reduced while, redness (a*) and yellowness (b*) values and cooking loss increased in all the samples. In addition, no *Salmonella* and *Escherichia coli* were detected in any sample while, total plate count and TBARS values were increased during the storage in all samples within the acceptable limits. As conclusion, inulin can be successfully used as a fat substitute in sausage production.

Keywords: Garlic, Meat quality, TBARS, *Salmonella*, Fat substitute

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Effects of Hik Tree (*Lannea coromandelica*) Wax on Internal and Sensory Attributes of Chicken Eggs Stored Under Room Temperature

P.M.U. Pushpakumara[1], H.M.J.C. Pitawala[2] and E.D.N.S. Abeyrathne[1]

[1]*Department of Animal Science, Uva Wellassa University, Badulla, Sri Lanka*
[2]*Department of Science and Technology, Uva Wellassa University, Badulla, Sri Lanka*

To increase the shelf life and to preserve the nutrient content under room temperature mineral oil used as an external coating material for eggs. But it is very expensive and dry slowly than other coating materials. Hik tree (*Lannea coromandelica*) is a tropical tree grown in dry zone in Sri Lanka and its wax has film forming properties. However, information on Hik tree wax coating on egg quality attributes does not exist. Therefore, this study was done to check the effect of Hik tree wax as an external coating material on shelf life, internal quality and sensory attributes of chicken eggs during storage under room temperature. Total of 306 white, medium sized, clean eggs were purchased from a commercial layer farm in Mahiyanganaya. Eggs were individually weighed and arranged under completely randomized design to 03 different coating treatments as Hik wax (HW), mineral oil (MO), and non-coated (NC) and stored under room temperature (27±2°C) for 6 weeks. Weight losses, Haugh unit (HU), albumen and yolk pH, air sack volume and microbial analysis for Salmonella sp. were determined weekly with 03 replicates. Sensory attributes of eggs were measured using 30 untrained panelists. FTIR analysis was conducted to analyze the structural changes in egg albumen. Results revealed that weight losses were minimum in MO coated eggs than in other treatments ($p<0.05$). HU decreased from 88.00 to 57.34 significantly in NC eggs compared with HW or MO ($p<0.05$). Albumen and yolk pH values increased during the storage in all treatments ($p>0.05$) and air sack volume increased from 0.41 cm to 0.71 cm during storage ($p>0.05$). However, grade of coated eggs reduced from AA to B within 04 weeks. All coated eggs were negative for *Salmonella* test during the study period. Color of the egg yolk did not change due to coating material ($p>0.05$). FTIR data confirmed that no chemical changes occurred due to wax coating. In conclusion, the present study confirmed that Hik tree wax can be used as an external coating material replacing MO.

Keywords: Hik tree wax, Mineral oil, Internal quality, *Salmonella*, Sensory properties

Development of Low-fat Chicken Meat Paste with Dried Bitter Gourd (*Momordica charantia*) Powder

A.D.R. Karunarathne[1], S.K.D. Wijesinghe[1], D.C. Mudannayake[1], A.G.A.W. Alakolanga[2] and D.D. Jayasena[1]

[1]*Department of Animal Science, Uva Wellassa University, Badulla, Sri Lanka*
[2]*Depatment of Export Agriculture, Uva Wellassa University, Badulla, Sri Lanka*

Chicken meat paste is one of the value added products which is popular among consumers mainly due to convenience. However, considerable number of consumers in Sri Lanka believes that meat products cause harmful effects on human health mainly due to the fat content. Hence, the aim of this study was to develop a value added low-fat meat paste from cheap cuts of chicken meat by incorporating bitter gourd. Chicken meat from cheap cuts was boiled to an internal temperature of 70 °C and minced. Then, it was mixed with other ingredients to make the meat paste according to a recipe developed through preliminary trials. Treatments were prepared by incorporating dried bitter gourd powder (DBGP) prepared using oven drying method (50 °C/8 hrs) at 1.0, 1.5, 2.0, 2.5 and 3.0% (w/w). Meat paste with no DBGP was used as the control. All treatments were then pasteurized at 85°C for 15 minutes. A sensory evaluation was conducted to select the two best concentration of DBGP to be added. Selected treatments and control were vacuum packed, and tested for the nutrient composition, physicochemical parameters, TBARS value, microbial quality, and antioxidant capacity over a one-month storage period under refrigerated condition (4°C).Meat paste with 1.5% and 2% (w/w) DBGP had the best sensory qualities ($p<0.05$). Meat paste with 2% (w/w) DBGP contained the highest ash content (4.82%) and water holding capacity (81.62%), and the lowest fat content (2.16%), pH value (6.45%) and colour parameters ($p<0.05$). In addition, meat paste with 2% (w/w) DBGP showed the highest antioxidant capacity (41.82%) among the treatments ($p<0.05$). Based on TBARS value and microbial data, DBGP incorporated meat paste can be kept without deterioration for 30 days under 4 °C. Therefore, DBGP at 1.5% and 2% (w/w) can be recommended to produce low fat meat paste with better sensory properties.

Keywords: Bitter gourd, Physicochemical, Meat paste, Sensory, Antioxidant capacity

Development of Cost Effective Jerky from Spent Hen Meat and Maize (*Zea mays*) Flour

L.D.T.N. Gunawardana, I.P.A.U.N.K. Illippangama and D.D. Jayasena

Department of Animal Science, Uva Wellassa University, Badulla, Sri Lanka

Jerky is a favorite, semi-dried and shelf stable meat based snack food in the world with high nutritive value. This study was conducted to develop jerky from spent hen meat by addition of maize flour (MF) for reducing the cost of production. Ground meat was mixed with ingredients, reformed into strips, and dried in an oven (85°C, 1½ h). Six treatments of spent hen meat jerky (SHJ) were prepared by changing the salt-pepper combination with and without bee honey. A sensory evaluation was conducted to select the best recipe and it was taken as the control. Four treatments were then prepared by replacing spent hen meat with MF at 3%, 6%, 9%, and 12% (w/w). Two best recipes were then selected from a sensory evaluation and they were vacuum packed and stored under the room temperature. The control sample and the two selected samples were tested for drying yield, meat quality traits, TBARS value, and microbial quality. First sensory evaluation showed that the highest overall acceptability was recorded for 1.5% (w/w) salt and 0.5% (w/w) black pepper combination without bee honey ($p<0.05$). According to the second sensory evaluation, SHJ with 3% and 6% (w/w) MF showed better overall acceptability ($p<0.05$). The drying yields of three treatments were comparable ($p>0.05$). The initial lightness and yellowness values of three SHJ were significantly different ($p<0.05$) and the redness value was comparable ($p>0.05$). SHJ with MF showed a higher ash content and lower pH, moisture, crude fat and crude protein contents than the control sample ($p<0.05$). SHJ with 6% (w/w) MF had the lowest fat content with the highest ash content ($p<0.05$). TBARS values for all treatments increased with 28-day storage period, but within the accepted limits; SHJ with MF showed lower TBARS values than the control sample ($p<0.05$). *Salmonella* and *Escherichia coli* were not detected in any sample. SHJ with 6% (w/w) MF had the lowest cost of production. These results suggested that, a cost effective jerky with better sensory and keeping qualities can be produced using spent hen meat with 6% (w/w) MF.

Keywords: Semi-dried, Keeping qualities, Sensory, TBARS

Development of a Simple Nontoxic Method to Extract Crude Fish Oil from Yellowfin Tuna (*Thunnus albacares)* Offal

G.M.V.T. Basuru[1], M.G.T.R. Kariyawasam[2], A.G.A.W. Alakolanga[3] and E.D.N.S. Abeyrathne[1]

[1]*Department of Animal Science, Uva Wellassa University, Badulla, Sri Lanka*
[2]*Ceylon Fresh Seafood (Pvt) Ltd, Ja-Ela 11350, Sri Lanka*
[3]*Department of Export Agriculture, Uva Wellassa University, Badulla, Sri Lanka*

Among world fish processing industry yellowfin tuna is a dominating species that is responsible for high amount of waste generation during processing which makes a high level of by-product. Fish by-products consist with omega-3 poly unsaturated fatty acids that are vital in food and pharmaceutical industry. The study was targeted to develop an effective fish oil extracting method from yellowfin tuna gut comparing with a current existing extraction technique. The determined proximate composition of yellowfin tuna gut showed 4.87±0.2% of crude fat. The research was conducted with completely randomized design (CRD) with two treatments; wet press method (rendering) and the solvent extraction method. As the solvents Chloroform/Methanol (standard), Acetone, Petroleum ether, n-Hexane, n-Butanol and Ethanol were used separately in 1:2 ratio (Gut sample: Solvent). Finally fish oil yields were calculated on percentages and analyzed the chemical property indices (Iodine value, Peroxide value and Acid value) of extracted fish oil. The results revealed that the highest yield (88.63±2.76%) was obtained in wet press method. In solvent extraction Acetone performed the highest yield (75.26±1.85%) showing the significant difference in comparison with oil yields of Petroleum ether, Hexane, n-Butanol and Ethanol ($p<0.05$).Iodine value of extracted fish oil from wet press method, Chloroform/Methanol, Acetone, Petroleum ether, n-Hexane, n-Butanol and Ethanol were 109.99±0.57, 103.94±0.56, 104.70±0.47, 104.53±0.74, 103.43±0.37, 106.15±0.86, and 105.83±0.68 respectively. The obtained peroxide value (2.98±0.05) and Acid value (1.04±0.02) of wet press method also indicated higher values than the solvent extraction method which assures that solvent extraction had a low hydrolysis and low oxidation in comparison with the wet press method. As conclusion extraction with acetone is better comparing the quality of the oil extracted.

Keywords: Fish oil, Extraction, Solvents, Omega-3, Oil yield

Comparative Study on Antioxidant Activity and Antimicrobial Activity of *Sargassum ilicifolium* Crude Extract Using Different Solvent Extractions

K.E.A.N. Edirisinghe, B.R.S. Bogahawaththa, E.D.N.S. Abeyrathna and M.K. Ranasinghe

Department of Animal Science, Uva Wellassa University, Badulla, Sri Lanka

Seaweeds are used for food, pharmaceutical and biochemical applications as they possess interesting biological activities. Amongst seaweeds, brown seaweeds show excellent antimicrobial, antioxidant and antiviral properties. *S. ilicifolium* is an economically important, underutilized seaweed species where more research opportunities are available. Hence, the present study was conducted to determine the functional properties of crude extracts of *S. ilicifolium* to find the best extract to develop as an ingredient for food industry. Dried and coarsely powdered samples of *S. ilicifolium* were subjected to solvent extraction using methanol, ethanol, chloroform and acetone. The yield, proximate analysis of crude extracts was determined while antioxidant activity was determined using DPPH and TBARS assays. Antimicrobial activity was determined against the *Staphylococcus aureus*. Significantly highest extraction yield was recorded in methanolic extraction (17.18±3.20%) while 9.60±2.14%, 2.80±0.59%, and 3.60±0.37% yields were obtained from ethanol, acetone and chloroform extractions, respectively ($P<0.05$). The highest carbohydrate (37.64±1.1%) and moisture (14.07±0.71%) were observed in methanolic crude extract. Highest ash content (37.15±4.90%) was observed in ethanolic crude extract. DPPH scavenging activity of the dried seaweed, methanolic and ethanolic crude extractions were 5.32±0.35%, 21.47±2.81%, 14.93±2.55% respectively ($P<0.05$). The malonaldehyde produced in dried seaweeds, chloroform and acetone extractions were recorded higher while ethanolic, methanolic extractions were showed lower than control. Antimicrobial assay against *S. aureus* did not show resistant to all the seaweed extracts. Hence, it could be concluded that the presence of bioactive components in the crude exacts of *S. ilicifolium* while highest components in ethanolic and methanolic extracts. Therefore, the ethanolic extract of *S. ilicifolium* could be a potential source as an ingredient for food industry.

Keywords: Seaweeds, *Silicifolium*, Crude extract, Bioactive compounds, Food industry

A Study on the Potential of Extraction of Roe Oil from *Thunnus albacares, Katsuwonus pelamis, Canthidermis maculata* and *Lepidocybium flavobrunneum*

D.S. Shanuke, A.C.W.W.M.C.L.K. Coswatte and S.C. Jayamanne

Department of Animal Science, Uva Wellassa University, Badulla, Sri Lanka

Fish oil contains essential polyunsaturated long chain fatty acids which are crucial for normal growth and survival of the fish. Food fish roe and fish waste contain oils in different levels. Even though roe of food fish has a lower demand in Sri Lanka, there is a potential of extracting edible fish roe oil and fatty acids. In this study, five different oil producing methods; heat and salt extraction, enzymatic hydrolysis, mechanical pressing and solvent extraction were tested with selected four fish species (*Thunnus albacares, Katsuwonus pelamis, Canthidermis maculata* and *Lepidocybium flavobrunneum*) to identify the best method and best fish roe type for edible roe oil production. Solvent extraction with 2-propanol was found to be the best method of producing roe oil considering oil yields (1.48±0.70 g: *T. albacares,* 1.33±0.10 g: *K. pelamis*, 1.27±0.25 g: *C. maculata* and 1.01±0.01 g: *F. flavobrunneum*). Hence, solvent extraction method was carried out for the selected matured roe of four species using four types of solvents: (50ml) 2-propanol, hexane, acetone and mixture of hexane and 2-propanol (70:30). Oil yields of roe in different maturation stages were (using 2-propanol) measured and compared. Highest oil yields were recorded by matured roe of (*K. pelamis*: 1.18±0.14 g, *T. albacares*: 1.03±0.32 g, *L. flavobrunneum*: 1.01±0.01 g and *C. maculata*: 0.94±0.52 g). Oil yields of immature roe in all four fish species were negligible. The results showed a significant difference between oil yields and solvents used for extraction ($P<0.05$). Highest oil yield was obtained (25 g of matured roe) as 1.60±0.26 g with acetone extraction for *T. albacares* followed by 2-propanol: hexane mixture, 2-propanol and hexane solvents were recorded oil yields of 1.43±0.89 g & 1.18±0.14 g for *K. pelamis* and 0.64±0.17 g for *T. albacares* respectively. It was revealed that roe of *T. albacares* is the most suitable for extraction of roe oil.

Keywords: Roe oil, Solvent extraction, Maturation

Evaluation of Sensory Qualities of Catla Fish (*Catla Catla*) in Three Selected Reservoirs of Badulla District, Uva Province, Sri Lanka

D.L. Leshika[1], T.K. Ediriweera[1], A.P Abeygunawardana[1], E.M.C. Siriwardana[2], G.G.N Thushari[1], N.P.P. Liyanage[1] and S.C. Jayamanne[1]

[1]*Department of Animal Science, Uva Wellassa University of Sri Lanka*
[2]*National Aquaculture Development Authority (NAQDA), Mapakada Wewa, Mapakada, Mahiyanganaya*

Catla (*Catla catla*) is one of the common exotic Indian carp species in inland fishery sector of Uva province in Sri Lanka. There is a high potential to develop Catla fish production and introduce value added products from the excess fish harvest. Environmental factors can significantly affect the physico-chemical and organoleptic quality of fish meat. Current study was focused on investigating Organoleptic properties of Catla fish flesh from 03 reservoirs selected (Ulhitiya, Rathkinda, Sorabora reservoir) with higher fish production in Badulla district. The fish samples with weight of 6.0 -12.5 kg and length of 65cm-95 cm were collected from the landing sites of three selected reservoirs. Prepared fish fillets were subjected to steam cooking for 10 minutes without adding spices at temperature of 100^0C. The sensory evaluation was conducted using 05-point hedonic scale to assess the sensory characters; color, texture, aroma, mouth feel, taste, overall acceptance of the steamed fish fillets by 30 untrained panelists. Sensory scores were statistically assessed through Friedman non parametric test. As results revealed, all the sensory parameters of flesh samples are significantly different according to the type of reservoir ($p<0.05$). Highest estimated median for all the organoleptic parameters (color/texture/aroma/mouth feel/taste=4, overall acceptance=5) were recorded for Catla flesh samples of Ulhitiya reservoir showing that, Catla fish from Ulhitiya reservoir has highest consumer preference. Sensory qualities of fish flesh depend on different kind of factors such as characteristics of living environment, fertility of water, availability of food and climatic condition. In conclusion, consumer acceptability also depends on organoleptic properties of fish samples. Detailed study on biochemical and physical quality changes of Catla fish samples in different reservoirs is recommended improve knowledge on fish quality.

Keywords: Carp fish varieties, Sensory parameters, Consumer acceptability, Environmental factors, Inland fishery

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Effect of Coagulation Temperature on Yield, Chemical, Sensory and Textural Properties of Buffalo Milk Paneer

T. Dishiwarthani[1], D.C. Mudannayake[1*], U.L.P. Mangalika[2] and J.M.D.R. Jayawardana[1]

[1]Department of Animal Science, Uva Wellassa University, Badulla, Sri Lanka
[2]Veterinary Research Institute, Department of Animal Production and Health, Gannoruwa, Sri Lanka

Paneer, popularly known as Indian cottage cheese is prepared by heat and acid coagulation of standardized buffalo milk. The present study was carried out to investigate the effect of different coagulation temperatures on yield, chemical, sensory and textural properties of paneer cheese coagulated with lime juice. Paneer cheese was prepared from whole or skimmed buffalo milk using different coagulation temperatures (70 ºC, 80 ºC and 90 ºC) and lime juice as the coagulant. Relevant milk coagulation temperatures were maintained using a constant temperature water bath, while a constant volume of lime juice (30 mL) with a pH of 2.3 at a temperature of 30 ºC was used as the coagulant. Sensory evaluation was done for fresh paneer samples with 30 untrained panelists, using a nine point hedonic scale. Texture of paneer cheese samples were analysed in terms of hardness, cohesiveness and springiness using CT3 texture analyser. Results revealed from completely randomized design indicated that the highest yields of both whole and skimmed paneer were obtained at coagulation temperature of 70 ºC. Moisture and protein content of paneer were significantly differed with different coagulation temperatures ($p<0.05$). However, fat and ash content of paneer were not significantly differed with different coagulation temperatures. According to the sensory evaluation, paneer sample prepared at a coagulation temperature of 80 ºC had a significantly higher overall acceptability. It was found that hardness and cohesiveness was increased with the coagulation temperature up to 90 ºC, whereas springiness increased with the temperature up to 80 ºC, and then decreased with the increase in temperature. The study showed that the coagulation temperature had a significant effect on chemical, sensory, and textural properties of paneer.

Keywords: Buffalo milk, Coagulant, Coagulation temperature, Paneer

Evaluation of Physiochemical Changes in Un-Boiled Eggs Stored at Different Temperatures

G.R.S.R. Eregama[1], A.L.Y.H. Aruppala[1], H.M.J. Pitawala[2] and E.D.N.S. Abeyrathne[1*]

[1]Department of Animal Science, Uva Wellassa University, Badulla, Sri Lanka
[2]Department of Science and Technology, Uva Wellassa University, Badulla, Sri Lanka

Eggs are considered as powerhouse of nutrients and also it is very popular food in the world due to its nutritional value. Among that, hard boiled eggs are widely used in ready-to-eat food processing industry. However, storing of hard boiled eggs under refrigeration and freezing conditions lead to some problems including rejection of customer demands due to its textural changes. Objective of this study was to check the effect of storing temperature on textural changes in un-boiled egg white with time. Medium sized brown shell eggs collected from commercial layer farm and stored under room temperature (27 ^{0}C), refrigeration (4 ^{0}C) and freezing (-18 ^{0}C) conditions for 0, 6, 12, 18, 24 and 48 hours. Then the stored eggs were boiled for 100 ^{0}C for 15 minutes and egg properties were studied under Fourier Transform Infrared (FTIR) spectroscopy (ALPHA), texture profile analysis using Texture analyzer (CT3), visual observation done by using gemological microscope and color was measured using colorimeter (CR 410 Chromo meter). Sensory qualities of boiled eggs were measured using 30 untrained panelists. According to the results, frozen eggs were showing low acceptance in all organoleptic properties checked ($p<0.05$). Hardness and gumminess of eggs were effected significantly during the storage in frozen eggs from the rest of the treatments ($p<0.05$). FTIR spectrums also confirm that the textural changes in bonds of amide A (3271 cm-1), amide I (1626.2 cm-1), amide II (1539.0 cm-1), C=O stretch of COO- (1397 cm-1), asymmetric PO2- stretch (1240 cm-1). However, the color of the egg white was not significantly different ($p>0.05$) among treatments. Sensory results revealed that frozen eggs after 12 hours did show low acceptance comparing the rest. As a conclusion storing temperature of un-boiled eggs has an effect on the texture of eggs after boiling.

Keywords: Un-Boiled eggs, FTIR, Temperature, Textural changes, Hardness of egg white

Development of Garlic (*Allium sativum L.*) Incorporated Synbiotic Butter

J.M.N.H. Premerathne[1] and D.C. Mudannayake[1*]

[1]*Department of Animal Science, Uva Wellassa University, Badulla, Sri Lanka*

Today consumers are looking for health beneficial synbiotic food products which contain both prebiotics and probiotics in order to prevent non-communicable diseases. Inulin is a prebiotic naturally and abundantly occurs in Garlic. Synbiotic butter with Garlic should be a new value added product concept to the Sri Lankan market. This study was conducted to develop garlic incorporated synbiotic butter and investigate the effect of garlic incorporation on survival of *Bifidobacterium animalis* subspecies *lactis* (Bb12) probiotic strain during long term refrigerated storage. Lyophilized garlic powder (LGP) was prepared using garlic bulbs and analyzed for its chemical composition. FTIR analysis was done for LGP and commercial chicory inulin to identify the presence of inulin. LGP was incorporated into butter at levels of 0%, 2%, 4%, 8% and 10% (w/w), while 5% (w/w) commercial chicory inulin incorporated butter was used as positive control. *B. animalis* 6% (v/v) was inoculated to cream (40% fat) before churning to ensure final count of $>10^6$ cfu/g. Viability of Bifidobacteria during 28 days of storage at 6°C was assessed at 7 day intervals. Bifidobacteria enumeration was carried out by pour plating on MRS media supplemented with 0.05% L-cysteine followed by anaerobic incubation. Sensory characteristics, proximate analysis, physico-chemical and microbiological parameters were analyzed in all six butter samples. FT-IR spectrums confirmed the presence of inulin in LGP. The highest scores in the sensory assessment were obtained by 10% garlic powder incorporated butter. Results of chemical (pH, titratable acidity, peroxide value) and microbiology analysis (*E. coli* count) were not deviated from SLS specifications for butter. In all samples viability of Bifidobacteria was increased up to 14 days of storage, and then reduced during 28 days of shelf life. The Bifidobacteria count (cfu/g) was increased with increasing garlic percentage compared to negative control sample (0% garlic), indicating that the prebiotic compounds in garlic such as inulin may have enhanced the growth of probiotic bacteria. The results concluded that garlic can be successfully used as a prebiotic source in synbiotic butter.

Keywords: *Bifidobacteria*, Bb12, Synbiotic, Butter

Comparative Analysis of Physicochemical and Sensory Attributes of Mature and Immature Tumid Venus Clam (*Gafrarium tumidum*) in Different Locations of Jaffna Lagoon, Sri Lanka

S. Jeyaamuthan, S.A. Kumar, J.M.D.R. Jayawardana, G.G.N. Thushari and D.K.D.D. Jayasena*

Department of Animal Science, Uva Wellassa University, Badulla, Sri Lanka

Tumid Venus clam (*Gafrarium tumidum*) is one of the dominant and readily available coastal bivalves consumed by local residents in Jaffna district of Sri Lanka. Scientific data on physicochemical and sensory attributes of this species is however scarce. Therefore, the objective of this study was to determine physicochemical and sensory attributes of Tumid Venus clam in four different sites of Jaffna lagoon at two different maturity stages. Randomly collected 200 clams from each different sites of Jaffna lagoon: Karainagar (9.7481°N, 79.8829°E), Mandaitivu (9.6165°N, 79.9920°E), Kayts (9.6526°N, 79.9081°E) and Navanthurai (9.6687°N, 80.0007°E) were graded into two maturity stages as mature (100 clams ≥35 mm in each location) and immature (100 clams <35 mm in each location) based on the shell length. The composite flesh samples were then subjected to analysis of physicochemical and organoleptic attributes using standard analytical protocols. Results revealed that there was a significant difference in color a* (redness), b* (yellowness), L* (lightness), pH value, water holding capacity, moisture and ash contents with the location as food availability is changed with inhabiting region ($p<0.05$). However, maturity stage had significant effects only on color a*, b* and L* values and water holding capacity ($p<0.05$). Based on the sensory evaluation, the appearance and taste of cooked clams were significantly varied with the location and maturity stage due to qualitative & quantitative changes of food items under different environmental conditions and variable nutritional requirements with maturity level ($p<0.05$). The highest consumer acceptance was recorded for immature bivalve samples from Navanthurai. In conclusion, current study showed the suitability of low cost bivalve resources as a substitute for conventional, expensive seafood sources. Furthermore, location and maturity stage had a significant effect on physiochemical and sensory attributes of Tumid Venus clam.

Keywords: Jaffna lagoon, Physicochemical attributes, Sensory, Tumid Venus Clam

Aquaculture and Fisheries: Oral Presentations

A Study on Variances in Sensory Properties and Meat Qualities of *Oreochromis niloticus* (L) with Their Sex, Size and Inhabiting Reservoir

W.D.S. Priyadarshani, N.P.P. Liyanage, Dinesh D. Jayasena, S.A. Kumar, H.K.T. Awanthika

Department of Animal Science, Uva Wellassa University, Badulla 90000, Sri Lanka

Nile tilapia *(Oreochromis niloticus)* is one of the commonly captured and highly preferred fish species in inland fisheries and also popularised as tastiest fish among the other freshwater fishes. However, there was a common belief among fisher communities as well as consumers that the taste of tilapia is varying from reservoir to reservoir. It is obvious that condition of the existing reservoir and available food items can affect quality and taste of the fish. Further, sensory qualities, ash and moisture content of fish flesh can be affected by age, sex, fat content, environmental factors and dietary ingredients. The present study aimed to determine the relationship of sensory qualities of Nile tilapia with sex, inhabiting reservoir and size of the fish. It also aimed to identify gut contents of fish samples collected. Male and female fishes from two size ranges were collected from three different reservoirs (Sorabora, Rathkinda, Nagadeepa) in Badulla district. First one third of the gut was immediately separated and preserved in 5% buffered formalin until subjected to gut content analysis. Fish samples were taken in to the Aquaculture laboratory of Uva Wellassa University and stored under -20 ^{0}C. Initially, moisture content, ash content, pH, cooking loss and water holding capacity of fish fillets were analysed. Parallelly, a sensory test was conducted using cooked tilapia flesh with 30 untrained panellists to identify the sensory properties i.e. taste, colour, appearance, odour, tenderness, juiciness, oiliness and overall acceptance. According to sensory evaluation, female fish in Sorabora reservoir with the size range of 300-500 g, recorded the highest score for overall acceptance. However, male fish collected from the same reservoir with the same size range obtained highest score for taste. Female fishes collected from Rathkinda reservoir in 300-500 g size range scored the lowest overall acceptance. Ash and moisture content of the fish samples collected showed significant difference ($p < 0.05$) with size and the inhabiting reservoir. Cooking loss showed a significant difference with inhabiting reservoir. Phytoplankton was identified as the dominant group present in the gut content of all the individuals analysed. Filamentous algae were the prominent organism in gut contents of fish samples collected from Sorabora reservoir and three identical zooplankton genera were also observed. However, further analysis is needed to evaluate the factors for variance in sensory and meat quality traits of fish samples.

Keywords: Fisheries, Fish flesh, Food science, Tilapia

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Development of a Prawn Flavored Spicy Cracker with Prawn Waste and Drumstick Leaves

A.M.L.K. Martyn, E.D.N.S. Abeyrathne
Department of Animal Science, Uva Wellassa University, Badulla, Sri Lanka

Prawns are very important aquatic products in Sri Lanka. Prawn industry wastes are used as value-added human food, fish feed or to extract chitin. This research intended to produce high protein spicy prawn cracker with prawn waste and drumstick leaves. Prawn industry wastes (head, appendages, carapaces, and shell) were thoroughly washed, dried in hot air oven at 80°C for 4 hours and ground by a blender. Fine prawn head waste powder thus obtained was used for producing prawn crackers. Drumstick leaves were wilted for 5 days at the room temperature and finely ground. Wheat flour, rice flour, vegetable oil, salt, dry yeast, pepper, water were mixed to make a dough. According to the sensory results 2% (w/w) prawn head waste powder and 1% (w/w) drumstick leaves powder was selected as the best. The dough was cut into pieces of square shapes and put into the oven at 180°C - 200°C for 8-10 minutes. Nutrition evaluation of prawn cracker was total carbohydrate 62.34%, crude protein 13.06%, crude fat 15.8%, ash 2.40% and crude fiber 2.50%. pH of the product did not significantly vary within the measured period (around pH 7). Microbiological analysis reveals that the product is within the SLSI limits in room temperature up to 14 days. Hygienic handling practices and proper packaging will increase the shelf life. This research revealed that high quality protein fortified prawn crackers could be manufactured from unutilized prawn wastes. Finally the development procedure can be scale up and can increase the shelf life with introducing proper packaging materials.

Keywords: Prawn head waste powder, Drumstick leaves powder, Prawn cracker

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Development of A Fish Burger Incorporating Sea Lettuce (*Ulva lactuca*) and Catla (*Catla catla*)

R. N. C. Kumarathunge, E.D.N.S. Abeyrathne
Department of Animal Science, Uva Wellassa University, Badulla, Sri Lanka

Catla fish has limited scope for consumption due to presence of intermuscular bones. This investigation was carried out to develop high protein and fiber containing ready to eat catla fish burger, incorporating seaweed (*Ulva lactuca*). Control fish burger was prepared without adding seaweed. Recipe development was carried out with different levels of spices. Suitable amount of spices were determined by preliminary trials. Four different levels (0.5%, 1%, 1.5% and 2%) of *Ulva lactuca* powder were tested. On the basis of sensory evaluation results; 0.5% (w/w) incorporated seaweed sample was found suitable due to significance difference ($p<0.05$) in taste, color, flavor, appearance and overall acceptability. Cooked burgers were packed in polyethylene bags in safety manner for further use. Proximate analysis revealed that seaweed incorporated fish burger contains higher amount of protein and fiber compared to regular fish burgers. Color of the burgers treated with seaweed (*Ulva lactuca*) showed significant difference for a* value compared with control. Shelf life studies were carried out by using microbiology and pH tests. The present study of seaweed incorporated fish burger showed slightly increased in pH from 5.47-6.47 up to 14th day where no significant increase observed ($p>0.05$). When pH of the control burger ranging from 6.16-6.6 stored at freeze temperature (-18^{0}C). E.*coli* and *Salmonella* they did not present in the both seaweed incorporated and control burgers which were negative in samples because of the hygienic preparation, handling of product and it is not subjected to cross contamination. Proximate composition of seaweed incorporated catla fish burger recorded as 62.83%, 16.25%, 2%, 12.43%, and 7.21% respectively for crude moisture, protein, fiber, fat and ash. It can be concluded that 0.5% (w/w) *Ulva lactuca* incorporated fish burger increase not only the protein and fiber content but also it fulfil the nutritional requirement of consumer.

Keywords: Fish burger, *Catlacatla*, Seaweed powder; *Ulva lactuca*

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Development of a Ready to Eat Breakfast Cereal with Incorporating Ovalbumin from Chicken Egg White

R.D.I.P. Randeniya, E.D.N.S. Abeyrathne
Department of Animal Science, Uva Wellassa University, Badulla, Sri Lanka

Ovalbumin incorporated breakfast cereal is a good source of protein with several functional properties. Shrinking the daily protein intake through breakfast associate with daily cognitive functions and obesity in long term. Formulation of breakfast cereal carried out several preliminary trials with different percentages of rice flour, chickpea, mung, cowpea, maize, skim milk powder and ovalbumin. Breakfast cereal was achieved by mixing 20 % rice, 6.67 % maize, mung pea, cowpea and sugar, 12 % chickpea, 3.34 % skim milk powder and ovalbumin, 0.67 % salt and vanilla with 33.3 % water. Protein content of the formula was reported as 15.12±0.53 % and protein calories reported high value of 17.34 % from total energy. Moisture and ash contents were noted to be high and low in fat (4.32±0.65%) content. High value of Bulk Density of 0.67±0.03 g/ml reported with desirable packing abilities. Lower water absorption capacity (WAC) 144.58±0.16 g/100g, of the product is desirable for nutrient uptake. High lightness and yellowness with low redness was reported (a*-3.96±0.36, b*-35.20±0.56 and L*-69.20±1.12), which results a desirable appearance. Microbiological count (Total Plate Count) was not exceeded the recommended level of ready to eat products up to forth week under room temperature storage condition. There was no *Salmonella* or coliform reported with same storage conditions. pH of the product did not vary with the period measured ($p>0.05$). Based on those facts this ovalbumin incorporated breakfast cereal can recommended as a good protein diet with low fat for adults and adolescent.

Keywords: Breakfast cereal, Ovalbumin

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A Feasibility Plan for Implementing Food Safety System Certification (FSSC) 22000 Standard, By Gap Analyzing of Existing Hazard Analysis and Critical Control Point (HACCP) System and FSSC 22000 Standard

W.A.S.M. Wirasagoda, D.K.D.D. Jayasena, E.D.N.S. Abeyrathne
Department of Animal Science, Uva Wellassa University, Badulla, Sri Lanka

Food safety is a scientific discipline describing handling, preparation, and storage of food to prevent foodborne illness. Food can transmit disease from person to person as well as serve as a growth medium for microorganisms. Over the years, many regional and customized food safety standards have evolved to enhance food safety and address the issues raised by manufacturers, suppliers, retailers and consumers. In 2005, ISO 22000 international food safety standard was developed and it specifies the requirements for a food safety management system. Latest standard for food safety is Food Safety System Certification (FSSC 22000) and it is slightly differ from ISO 22000 food safety standard. This study was carried out to identify the gap between implementing HACCP system and FSSC 22000 standard and check the feasibility to fill the gap in Gills food products (Pvt) Ltd. To analyze the gap, solution selection matrix theory was applied. According to that, the most effective solutions were selected from a suggested list of solutions. 37 solutions were suggested to overcome the requirements in the proposed standard. Then, solutions were ranked from 1 to 37 according to the frequency, implementing feasibility and economic feasibility parameters. Total score was calculated by adding up scores of those three parameters. By considering total scores, solutions were ranked and those scores were considered as effectiveness of solutions. Finally, using the effectiveness value, most effective 25 solutions were selected to implement because it fulfills 96% of requirements. Other than not-established requirements, some solutions were added to solution list to improve already established requirements according to company need. Therefore, solutions were suggested not only for applying FSSC standard, but also improve the company condition to ensure food safety and be capable to apply other standards in future.

Keywords: Food safety, HACCP, FSSC 22000, Gap analyzing, Solution selection matrix

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Development of a Fish Paste Incorporated with Mature Flower Buds of *Rhizophora apiculate* as a Nutritional Supplement

T.H.S.Tharaka, E.D.N.S. Abeyrathne
Department of Animal Science, Uva Wellassa University, Badulla, Sri Lanka

Indian carps (*Catla catla*) are considered as an excellent source of high proteins, vitamins and minerals and they are low in saturated fats. However, carps have limited consumer acceptability due to presence of intramuscular bones. Recent studies showed that mangroves provide priceless therapeutic agents in both modern and traditional medicines systems. Present study was conducted to develop a value added fish paste incorporating mature flower buds of *Rhizophora apiculata* which can be used as a nutritional and medicinal supplement. Fish paste was prepared mixing with boiled and minced fish with adequate amounts of other ingredients. Finally, it was pasteurized at 85°C for 15 minutes. Preliminary investigations were conducted to determine the suitable levels of all ingredients with 30 untrained panellists. According to the results, 89% (w/w) of catla, 6% (w/w) of mature flower buds of *Rhizophora apiculata*, 1% (w/w) chili, 1% (w/w) salt, 1.5% (w/w) white pepper and 1.5% (w/w) lime juice were determined as the best ($P<0.05$). Proximate analysis showed that final product contained 72.50±0.03%, 20.82±1.49%, 2.81±0.02%, 2.10±0.11% and 1.94±0.01% of moisture, protein, fat, fiber and ash, respectively. Shelf life studies of bread spread were carried out using microbiological and pH tests. In addition pH of the fish paste did not change significantly during the storage period of 30 days under refrigerated condition ($p>0.05$). According to the microbiological observations, total coliform and *Salmonella* were absent while total plate counts were within the acceptable level for 28 days. Therefore the developed fish paste can be considered as a safe food for the consumers up to 28 days which can provide high nutritional and medicinal benefits.

Keywords: *Catla catla*, Bread spread, *Rhizophora apiculata*, Sensory evaluations, Shelf life studies

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Effect of Frying in Different Cooking Oils on the Fatty Acid Profile and Sensory Characteristics of Tilapia (*Oreochromis niloticus*) Fillets

N.F.K.R. Fernando, G.G.N. Thushari, D.K.D.D. Jayasena
Department of Animal Science, Uva Wellassa University, Badulla, Sri Lanka

Fish is one of the most abundant sources of essential fatty acids. Among many fish species, Nile tilapia (*Oreochromis niloticus*) is a popular culture species in aquaculture industry and they heavily contribute to the worldwide fish consumption. Fish is mainly consumed in fried forms in many countries and the alterations in the fatty acid composition during frying process may have significant effects to human health. This study was performed to determine the effects of frying with three different cooking oils (soybean, sunflower and coconut oil) on the fatty acid profiles and sensory characteristics of tilapia fillets. Fish were purchased from local fish shop in Badulla and transported to the university laboratory under chilled condition. Tilapia fillets were deep fried in the three different cooking oils separately and the fatty acid composition of each group was evaluated using gas chromatography. The fat content of the fillets increased after frying in all evaluated samples ($P<0.05$). Mean saturated (SFA), monounsaturated (MUFA), polyunsaturated (PUFA) fatty acids, Total ($\sum$) -3 and $\sum$-6 contents of raw fillets were 43.26±0.55, 29.90±1.26, 26.31±1.65, 15.43±1.17 and 10.88±0.53%, respectively. Frying led to exchange of fatty acids between the tilapia fillets and cooking oils. As a result of interactions, PUFA, $\sum$-6 and PUFA/SFA ratio of samples fried in soybean and sunflower oil significantly increased while the amounts of SFA decreased ($P<0.05$). Frying had a negative effect on the $\sum$-3, EPA and DHA amounts in all fried samples. $\sum$-6/-3 ratio was optimum in soybean oil fried samples while sunflower and coconut oil fried samples values were not in the recommended level to health. Frying with coconut oil showed high SFA, MUFA and low PUFA levels among all samples. In concern to sensory results, both sunflower and soybean oil-fried samples obtained positive results. By considering all the facts, soybean oil can be considered as the best cooking oil to fry tilapia fillets.

Keywords: Tilapia, Deep frying, Soybean oil, Coconut oil, Fatty acids

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Development of drinking yoghurt by incorporating corn (*Zea mays*) milk and corn seeds

R.I.W. Mendis, A.M.N.L. Abesinghe, A.M. Samaraweera
Faculty of Animal Science and Export Agriculture, Uva Wellassa University of Sri Lanka

and

L.K.A. Gunawardhane
Lucky Lanka Milk Processing Company Limited, Sri Lanka

Introduction

Cereal grains are considered as important sources of dietary proteins, carbohydrates, vitamins, minerals and fiber for people all over the world (Chavan and Kadam, 1989). Corn (*Zea mays*) is locally grown cereal that can be purchased at low price from several areas in Sri Lanka. Corn milk is considered as a new innovation, especially in making yoghurt based products. Vegetable based corn milk yoghurt is an alternative to substitute the cow milk based yoghurt. Drinking yogurt is the fastest growing food and beverage category in worldwide (Yasni and Maulidya, 2013). However, still value added drinking yoghurts are rare in Sri Lankan market. Adding cereal grains is a perfect way to upgrade a drink to a nutritious breakfast. Therefore, this study was conducted to develop yoghurt by incorporating corn *(Zea mays)* milk and corn seed to cow milk.

Methodology

The study was carried out at Lucky Lanka Milk Processing Com. Ltd (LLMP), Matara and Uva Wellassa University. Six experimental trials with different treatments were conducted. In trial I, mature fresh corn seeds, mature boiled corn seeds and germinated corn seeds were separately used to extract corn milk and the best extract of corn milk was evaluated by sensory properties (odor, taste, color and mouth feel) using untrained panelist. In trial II the most compatible sugar (8%, 9% and 10% w/v) and gelatin (0%, 0.2% and 0.4% w/v) levels for different corn milk percentages (5%, 10%, 15% and 20% w/v) were identified. After selection of appropriate combinations of sugar and gelatin levels, trial III was done to select the best corn milk incorporation level by narrow downing the corn milk percentages (6%, 8%, 10%, 12% and 14%). Preserved in sugar syrup and boiled corn seeds were crushed into two sizes (> 3.15 mm and 2 mm –3. 15 mm) to prepare different types of corn seeds. Trial IV was carried out to select best corn seeds particles on the textural basis and trial V was done to assess the consumer acceptability for the presence of corn seeds in the corn milk incorporated drinking yoghurt. Finally three treatments (trial VI) were prepared and evaluated on sensory, chemical and microbiological properties. The sensory evaluation was done using 35 untrained panelists. In chemical analysis, proximate analysis (moisture content, crude fat, total solid, crude protein, ash and crude fiber content) was conducted. pH value and titratable acidity were evaluated and microbiological analysis was done for Yeast and Moulds, and *Escherichia coli* for three weeks in one day interval. The sensory data were analyzed using Friedman

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nonparametric test. Complete Randomized Design was conducted and data obtained from chemical and microbiological tests were analyzed by Analysis of Variance using the General Linear Model procedure of SAS. Significant means of treatments were separated using the Least Significant Difference test (P< 0.05).

Result and Discussion

In trial I, boiled corn seeds (mature) based method was selected to extract corn milk. Other two methods were rejected due to the unpleasant odour and taste which may be due to the activation of various food enzymes and breaking down the higher molecular components to simple molecules during germination.

Eight per cent sugar (w/v) for 5% corn milk (w/v) and 10% sugar (w/v) for other 10%, 15% and 20% corn milk (w/v) incorporation levels were selected due to desirable sweetness. The gelatin level (w/v) was selected as 0% due to the presence of appropriate drinking yoghurt properties including texture, mouth feel, appearance and viscosity. The whey separation has been prevented by stabilizing effect of corn starch in corn milk.

In sensory evaluation, 8% corn milk incorporation level was significantly highly preferred by panelist with respect to mouth feel, taste and overall acceptability (P<0.05). However, there is no significant difference in color and aroma of the three treatments (P>0.05) (Figure 01). Addition of corn milk had no influence to change colour and aroma of the product.

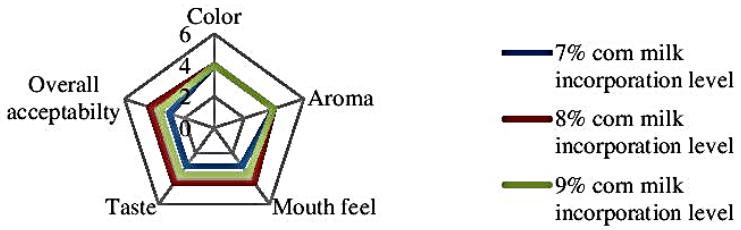

Figure 01. Web diagram for level of corn milk incorporation in sensory evaluation

In trial IV, sugar syrup based method was rejected due to hardness of the seeds and crushed boiled corn seeds were selected. Further, the sensory results revealed that the preference (taste, aroma, mouth feel, color and overall acceptability) for corn seeds >3.15 mm or 2 mm to 3.15 mm particles incorporated drinking yoghurt is less whereas preference for corn milk incorporated drinking yoghurt without corn seeds was high. The observed difference is due to the disturbance for the drinkable property of product by presence of corn seed particles. The composition of the selected corn milk incorporated drinking yogurt is given in Table 01.

There was a significant difference between treatments for change in pH with the storage period (P<0.05). pH values of the T8 (with preservative) and control were not changed dramatically. Control of pH by potassium sorbate could be due to inhibition of the activity of starter culture by inhibiting various enzymes in microbial cell (Rajapaksha *et al*., 2013).

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There was a significant difference between treatments with respect to acidity ($P<0.05$) and titratable acidity increased significantly with storage period and in treatments without preservatives. According to Rajapaksha *et al.* (2013), titratable acidity of yogurts increased over the time and acidity of yoghurt without potassium sorbate increases drastically than other treatments reflecting the inhibitory activity of potassium sorbate on post fermentation.

Table 01. Composition of select corn milk incorporated drinking yoghurt

Raw material	Percentage	Quantity (g)
Milk	79.54%	867.03
Dairy cream	1.03%	11.33
SMP	1.42%	15.49
Corn milk	8.00%	87.20
Sugar	10.00%	109.00
Total	100.00%	1090.00

There were no contaminations with Coliform and *Escherichia coli* and thus safe for human consumption. There were no yeast colonies in T8 and control sample. At day 11, yeast colonies were exceed the SLS standards of <1000 only in T7 (without preservative).

Proximate analysis revealed all the physiochemical characteristics of corn incorporated drinking yogurt (protein, fat, ash, fiber and total solid), except moisture significantly higher compared to plain drinking yoghurt ($P<0.05$). Usually drinking yoghurt does not contain fiber. However, due to addition of corn, milk fiber was increased up to 0.5%.

Conclusion

Eight per cent corn milk incorporation level with selected sugar (10%) and gelatin (0%) level has best consumer preference with respect to the taste, mouth feel and overall acceptability ($P<0.05$). Moreover, drinking yoghurt without corn seed particles is preferred by the panelists. Shelf life of product without potassium sorbate is around 11 days at 4 °C with respect to microbiological analysis and physiochemical analysis.

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Development of Finger millet *(Eleusinecoracana)* incorporated symbiotic drinking yoghurt

H.K.T. Awanthika, A.M.N.L. Abesinghe
Faculty of Animal Science and Export Agriculture, UvaWellassa University of Sri Lanka

and

U. De Silva
Ceylon cold stores PLC, Samadaragahawatta ,Ranala, Sri Lanka

Introduction

Sri Lankan yogurt market is characterized by intense competition prompting leading players to differentiate themselves by focusing on health benefits, branding, and incorporation of different ingredients. Yoghurt is a popular fermented dairy product due to its health benefits as a functional food in addition to its nutritional benefits (Robinson and Tamime, 1999). High calorie yogurt drink that contains any kind of a cereal powder is completely a new product concept to the Sri Lankan market. Therefore, the objective of the current study was to develop a health beneficial probiotic drinking yoghurt by incorporating finger millet as a cereal which can be used as a breakfast food, sport supplement and also as a weaned food for toddlers. Nutritionally, finger millet is used as a whole grain, it is higher in protein and minerals in comparison to all other cereals and millets. Accroding to previous studies, finger millet is also known for several health benefits such as anti-diabetic, antitumerogenic, atherosclerogenic effects, antioxidant and antimicrobial properties which are mainly attributed due to its polyphenol and dietary fiber contents (Dykes and Rooney, 2007; Chethan, 2008). Therefore this study was conducted to develop a cereal based probiotic yoghurt drink which can be promoted as a natural source of high calorie that can be consumed as an alternative for the imported, artificial and expensive sport nutrition's and weaned foods.

Methodology

The study was conducted at the research and development and quality assurance laboratories in Ceylon cold stores PLC, Ranala, Kaduwela. In the preliminary trial 1 most compatible sugar percentages for different incorporation levels of finger millet flour from the three experimental forms (roasted flour, germinated flour and raw slurry) were selected. Then preliminary trial 2 was carried out using ranking method to select the best finger millet incorporation levels (4 %, 5 %, 6%, 7% and 8 % (w/w)) for each incorporation form. The best sugar percentages and incorporation levels of finger millet from preliminary trials were used in next steps of

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experiments. Sensory evaluation 1 was carried out to select the best form/type of finger millet flour to incorporate out of three forms. In second sensory evaluation, the most suitable stage for finger millet incorporation was determined by using two treatments. Each sensory evaluation was conducted with 30 untrained panellists and color, taste, aroma, mouth feel and overall acceptability were considered as sensory properties. Finally proximate analysis, physico- chemical and microbial analysis were conducted for the selected final probiotic drinking yoghurt by comparing with a control sample. Probiotc lactic acid bacteria enumeration was carried out using the selected final product by pour plating on MRS media to find out the effect of finger millet incorporation on the viability of probiotic lactobacilli. Selected final product was compared with a control sample and enumeration was done at 1, 7 and 14 days interval.

The sensory data were analyzed using Friedman non-parametric test with 95% significance by using Minitab 16 software. Complete Randomized Design (CRD) was conducted and data obtained from chemical and microbiological tests were analyzed using analysis of variance (ANOVA) using the SAS 9.0 software. Significant means of treatments were separated using the Least Significant Difference test (LSD) ($P< 0.05$).

Results and Discussion

According to the results of the series of preliminary trials 5% (w/w) was selected as the best incorporation level from each three finger millet forms and 8 % (w/w) sugar as the compatible sugar percentage. In the first sensory evaluation for selecting best form/type of incorporation out of three experimental forms, germinated /malted flour incorporated yoghurt was selected as the best due to higher preference than other two. There was a significant difference ($P<0.05$) between treatments regarding and overall acceptability. Second sensory evaluation revealed, 5 % (w/w) germinated (malted) finger millet flour incorporated (Addition before fermentation) drinking yoghurt have the higher preference compared to the other treatment with respect toall the sensory parameters considered ($p<0.05$). The selected composition of synbiotic drinking yoghurt is given in Table 01.

Table 01. Composition of the selected final product

Ingredient	Percentage (w/w)
Raw milk	84.54 %
Sugar	8 %
Stabilizer	0.25 %
Finger millet (Germinated flour)	5 %
Skim milk powder	0.83 %
Dairy cream	1.37 %

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In the shelf life evaluation of the final product, there was a significant difference ($p < 0.05$) in lactic acid development (Titratable acidity) during cold storage between control drinking yoghurt sample and germinated finger millet flour incorporated yoghurt.

During the 21 days of storage period, titratable acidity of the selected final product was between 0.68% ± 0.08 to 0.89% ± 0.08. During the storage period of 21 days, pH of the control yoghurt sample reduced from 4.58± 0.09 to 4.25±0.09 and pH of germinated finger millet flour incorporated yoghurt reduced from 4.62±0.09 to 4.38±0.09. The pH drop of both treatments is due to the acid development as a result of the activity of lactic acid bacteria (Tammie and Robinson, 1999).Yeast andmold and *E.coli*, Coliform counts of the both germinated finger millet flour incorporated drinking yoghurt and control were not exceeding SLS standards for yoghurt during 21 days of refrigerated storage.

The probiotic *lactobacilli* count in both experimental and control yoghurt samples have decreased over the storage period (Figure 1). Reason for that may be the low pH (high acid development with the time) levels.Low pH level of the fermented milk products was directly affected the survival of probiotic bacteria. However, as shown in the figure probiotic *lactobacilli*population in germinated finger millet flour incorporated drinking yoghurt is higher compared to the control sample. Finger millet contains prebiotic substances such as resistant starch, oligosaccharides, crude fibers and also it acts as fermentable substrates for growth of probiotic microorganisms (Dykes and Rooney, 2007; Chethan, 2008). There is a significant difference in probiotic bacteria population over the storage period between control and germinated finger millet flour incorporated yoghurt sample ($p < 0.05$).

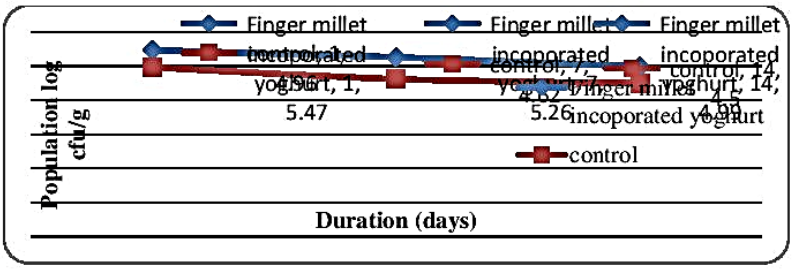

Figure 01: Changes of probiotic lactobacilli population during refrigerated storage

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Conclusions

5 % (w/w) finger millet flour incorporation level was selected as the best and germinated/malted flour was selected as the best form of incorporation while addition of finger millet before fermentation was determined as the most suitable stage of incorporation. Further, the incorporation of finger millet into the yoghurt has enhanced the survival of probiotic *lactobacilli* during refrigerated storage.

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Development of garment leather from Yellowfin tuna (*Thunnus albacares*) skin

E.M.B.S. Eakanayake and S.C. Jayamanne
Faculty of Animal Science and Export Agriculture, Uva Wellassa University of Sri Lanka

and

W. Wickramasinghe
Ceylon Leather Product PLC, No 115/1, Kelaniganga Mill Road, Mattakkuliya, Sri Lanka

Introduction

Leather is defined as hide or skin with its original fibrous structure more or less intact, tanned to prevent putrefaction (Covington, 2009). Due to tanning, skins that have been processed to prevent putrefaction retain its characteristics such as flexibility and toughness. Hides and skins from cattle, buffalo, sheep, pig, goat, horse, crocodile, snake and fish are used for leather production. When considering the fish leather, fish skins are used for production of leather after tanning and re-tanning processes. Texture of fish leather depends on pocket size of the scales. Presently, carp, pacific salmon, bass, sturgeon, shark, tuna, catfish, salmon, tilapia and several other fish species are taken for leather production. Garment leather is tanned with chrome and treated with softeners. The quality of the garment leather should be thin enough to use on garments and it should feels softer and smoother than any other types of leather. These types of leathers are made from the top-grain of a hide. Good stitch tensile strength and light weight are some other characters of garment leathers. Cow hide and skins from deer, pig and lamb are commonly used for garment leather manufacturing. But there is a potential to develop garment leather from fish skin similar to other garment leathers. The present study was carried out to add value to waste generated during the Yellowfin tuna (*Thunnus albacares*) fish processing and promote a fish leather production in Sri Lanka through developing garment type leather using discarded skins. At present, hides and skins from cattle, buffalo, sheep and goat are used for leather production. In addition, fish species including carp, pacific salmon, shark, tuna, catfish and tilapia are taken for leather production in the world. The objectives of this study were to find out the best fat liquor percentage to obtain maximum softness of chrome-tanned Yellowfin tuna fish leather and to find out the best tanning method for garment leather production from Yellowfin tuna skin.

Methodology

The current study was carried out at the tannery of Ceylon Leather Product PLC (CLP), Mattakkuliya. Tuna skins were collected from the processing factory of Jay Sea Food (Pvt) Ltd in Ja-Ela. Two experiments were carried out to find out best fat liquor concentration and best tanning method. In experiment 1, yellowfin tuna skins were treated with 33% basic chromium sulphate and five different concentrations (12%, 14%, 16%, 18% and 20%) of fat liquors (on weight of pelt). In experiment 2, yellowfin tuna skins were treated with four different tanning methods (Full chrome tanning, full vegetable tanning and two types of semi chrome tanning methods - vegetable tanned skins directly tanned with chrome and vegetable tanned skins tanned with chrome after stripping with $NaHCO_3$). Before initiating the experiments pre-trial was conducted to find out the optimum conditions for liming. Six pieces of raw skins were immersed in solutions of 0.25%, 0.5% and 1% Na_2S, 6% $Ca(OH)_2$ and 200% water (on weight of skins). One day after, skins were taken out and scales and flesh were removed. Then, skins were kept for another 5 days in a new 6% $Ca(OH)_2$ solution. Weight

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and the physical conditions (scale pockets, colour and plumpness) of the skin were observed daily. After identifying the optimum conditions for liming 40 skins were subjected to 8 production process steps (liming, de-liming, pickling, tanning, basifying, fat-liquoring, fixing, drying and dying). Experiment 1 was done in fat-liquoring step and experiment 2 was done in tanning step. Then, the dried leathers were dyed and waxed. Finally softness, feel, tensile strength, tear strength and stitch tear strength were measured in developed leathers. Physical evaluation was done to check softness and feel by ten expertise. Tensile strength, tear strength and stitch tear strength were done using universal testing machine. This experiment was designed according to Complete Randomized Design (CRD). The collected data were analyzed using Friedman test and one-way ANOVA in MINITAB 16 and SPSS 22 statistical analyzing software to find out the significant difference between treatments. Mean separation was done using pairwise comparison.

Chemicals percentages were weighted according to the weight of skins, used in experiment 1 and 2.

Results and Discussion

According to pre-trial, 0.5% Na_2S solution was identified for descaling with 6% $Ca(OH)_2$ and 200% H_2O. For liming it was identified that immersing for 4 days is the best method in 6% $Ca(OH)_2$ and 200% H_2O solution.

In experiment 1 (from the five different concentrations of fat liquors), there was a significant effect on treatment method on tensile strength, tear strength and stitch tear strength ($P<0.05$). Maximum tensile strength and tear strength values were observed in 16% fat-liquored leather with average values of 23.46 ± 6.06 N/mm^2 and 401.59 ± 77.75 N/mm, respectively meanwhile 18% fat-liquored leather showed the highest stitch tear strength (187.91 ± 5.39 N/mm). There was a significant treatment effect on softness of leather ($P<0.05$) and on feel of leather ($P<0.05$). According to the ranking values, treatment 4 (18% fat liquor) showed the best response for softness (Ranking value= 46.5) and feel (Ranking value = 47.0) compared with the other treatments.

While adding fat-liquors, it improves the tensile strength of leathers (Tex Biosciences, 2008). But increasing the fat liquor concentration further leads to decreasing of the ability to make fine emulsion as well as reduction of the ability of fat liquor penetration in to collagen fiber. Hence, softness is reduced when increasing the fat liquor concentration therefore, the hardness of leather is increased (Gutterres and Melo dos Santos, 2009). It may be the reason for reduction of tensile strength.

Increasing and again decreasing of the values of tear strength and stitch tear strength may be due to the decreasing of the ability to make fine emulsion. Hence, ability of fat liquor penetration in to collagen fibers was decreased. The reason for increasing softness might be fat liquor which acts as a lubricant in between collagen fibers (Gutterres and Melo dos Santos, 2009). Reason for increasing and again decreasing the softness maybe due to the decreasing of the ability to make fine emulsion. Therefore, the ability of fat liquor penetration in to collagen fibers is decreased. Hence, it can be suggested to use 18% fat liquor concentration to produce garment type leather from yellowfin tuna skin.

From the four tanning methods studied in experiment 2, there was no significant effect of treatment on tensile strength ($P>0.05$). But full chrome tanned leather showed the highest value for tensile strength (22.56 ± 0.86 N/mm^2). When considering the tear strength there was no significant effect of treatment ($P>0.05$). Highest value of tear strength showed the full chrome tanned leather (373.75 ± 23.20 N/mm). But there was a significant effect of treatment on stitch tear strength ($P<0.05$). Highest value of stitch tear strength showed the full chrome tanned leather (187.91 ± 5.39 N/mm). There was a significant treatment effect on softness of leather and on feel of leather ($P<0.05$). In addition, the highest ranking value for softness (30.0) was observed in full-chrome tanned leather. Hence, it can

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be suggested to use full chrome tanning with 18% fat-liquor concentration to produce garment type leather from yellowfin tuna skin.

There was no effect from fat liquor concentration and surface treatment on tensile strength, tear strength, stitch tear strength, softness and feel due to equal fat liquor concentration (18%) and surface treatment (wax). Reason for no significant effect of treatment on tensile strength and tear strength might be due to the reason that tensile strength and tear strength are only dependent on the fiber structure of the skin. Fish skin has a cross fiber structure (Hebrank and Hebrank, 1986). Reason for high value for stitch tear strength might be due to the high amount of covalent bonds between chromium sulphate and collagen fibers in full chrome tanned leather. Vegetable tanned leather hardness was higher than the chrome tanned leather. Hence, softness is higher in full chromed tanned leather than the vegetable tanned leather. When considering the tanning agents chromium sulphate makes covalent bonds with collagen fibers and mimosa acts as a filling agent between collagen fibers.

Conclusion

According to the results obtained in this study, the best fat-liquor concentration was 18% to prepare soft garment leather from yellowfin tuna skin. The most effective tanning method was the full chrome tanning compared to full vegetable tanning and semi tanning methods. Using this combination a marketable garment leather from yellowfin tuna skin can be produced. This could be used to produce commercially valuable products such as ready-made garments.

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Development of Chicken Sausages by Incorporating Pulses as a Source of Micronutrients

K.A.D.O.P. Kuruppu, R.M.H.Tharangani, N.P.P. Liyanage
Uva Wellassa University, Badulla, Sri Lanka

and

N.C.Sooriaarachchi
Nelna Farm (Pvt) Ltd, Meethirigala, Sri Lanka

Introduction

The increasing pressure of the world population and the need to raise the living standards, have created the need to produce better meals in large scale. Hence, the consumption of meat products has increased and the processing of meat products developed accordingly (Lawrie, 1979). Consumers today eat sausages because of convenience, variety, economy and nutritional value. The great variety of sausage makes it possible to serve many different products, each having its own characteristic appeal and flavor (Pearson and Gillett, 1996). Pulses are annual leguminous crops which have significant nutritional and health advantages for consumers because they are important due to their high protein, essential amino acid content and especially the micro nutrient content such as iron, zinc and selenium (Majumdar, 2011). Present study was intended to fulfill certain objectives such as developing a sausage by incorporating pulses as a source of micronutrients, to evaluating subjective qualities, objective qualities and the proximate composition of the products and finding out the best type of pulse incorporated sausage with improved organoleptic properties.

Methodology

The research was carried out at the Nelna Farm (Pvt) Ltd, Meethirigala, Sri Lanka. Four types of pulses were used such as dhal (*Lens culinaris*), cowpea (*Vigna unguiculata*), chickpea (*Cicer arietinum*) and green gram (*Vigna radiata*) to incorporate in chicken sausages by replacing bread crumbs. At first, four preliminary trials were conducted to find out the best percentage of a particular pulse by changing the ratio of the pulse and bread crumbs while maintaining all other ingredients at a constant level. In preliminary trials, three treatments were prepared for each pulse with the ratios of pulse: bread crumbs as 25%: 75%, 50%: 50% and 75%: 25% out of 10% which is the percentage of bread crumbs generally used in sausage preparation at Nelna company. Sensory evaluation was conducted for each preliminary trial to select the best ingredient combination. Then the final experiment was done to select the best type of pulse incorporated in sausage preparation and the sensory evaluation was conducted by using 30 untrained panelists at Nelna company and Uva Wellassa University. The results were analyzed by using Friedman nonparametric statistical test in MINITAB 14 software.

The products were stored at -18°C temperature throughout the testing period. Microbiological analysis, keeping quality analysis and chemical analysis were carried out for the four types of pulse incorporated sausage samples by using commercial chicken sausage as the control. Objective measurements and proximate analysis were conducted for all four treatments with the control.

Proximate analysis was done to measure crude protein, crude fat, crude fiber, moisture and ash (AOAC, 1995). Objective measurement was done by analyzing pH value and water holding capacity.

Microbiology tests were also done as a part of shelf life study and in which, samples were taken at four days with five days intervals. The results were analyzed by using one way ANOVA procedure in MINITAB 14 software.

Results and Discussion

According to the results of four preliminary trials, no significant difference ($P<0.05$) observed between the samples in relation to appearance, texture, tenderness, and juiciness. Aroma, flavor and overall acceptability were the only characters which showed a significant difference ($P<0.05$) between the samples. 25% of dhal (T1), 25% of cowpea (T2), 50% of chickpea (T3) and 50% of green gram (T4) incorporated sausages were selected as the best percentages incorporated for the chicken sausage from the results of preliminary trials. Based on the final experiment, 25% of dhal incorporated chicken sausage was given the highest scores for the aroma, texture, flavor, tenderness and overall acceptability because there was a significant difference ($p<0.05$) between the treatments T1, T2, T3 and T4 and T1 showed the highest estimated median value (Table 1).

Table 1 Sensory Results of pulse incorporated chicken sausages

Quality character	Median values of treatments (T)				Control	P value
	T1	T2	T3	T4		
Appearance	4.0000	4.0000	4.0000	4.0000	4.1000	0.062
Aroma	*4.0000	3.9000	3.9000	3.5000	3.9000	0.038
Texture	*4.1000	3.9000	3.9000	4.0000	4.0000	0.047
Flavor	*4.1000	3.5000	3.9000	4.0000	4.0000	0.019
Tenderness	*4.0000	3.8000	3.9000	3.5000	4.1000	0.028
Juiciness	4.0000	4.0000	4.0000	4.0000	4.0000	0.448
Overall acceptability	*4.1000	3.7000	4.0000	3.7000	4.1000	0.032

*n–values indicates the highest estimated median for particular sensory character at $p< 0.05$

Treatment 1, 2, 3 and 4 were not significantly different ($P<0.05$) in pH and Water Holding Capacity. According to the results of microbiological analysis, *Escherichia coli* were not detected during the storage period. *Staphylococcus aureus* counts and TPC were in satisfactory level.

According to the results of proximate analysis, there was a significant difference ($P<0.05$) among treatments T1, T2, T3 and T4 in relation to moisture, crude protein, crude fat, crude

fiber and ash content. T1 showed the highest median values in crude protein, crude fiber and ash content as 11.1%, 1.7% and 3.5% respectively.

The cost of production was calculated for 1 kg of sausages. Finally selected best sample from sensory evaluation 05 had the lowest cost out of all four types of pulse incorporated sausages. Even though the price of dhal is high, the cost of production in finally selected dhal incorporated sausage was only 50 cents.

Conclusion

It is evident that high consumer preference was obtained for dhal incorporated sausage which gives a better taste. The cost of production of dhal incorporated sausage was nearly same to the commercial chicken sausage and is economically feasible. Finally, the best pulse incorporated sausage with high micro nutrients was selected as dhal incorporated sausage at the ratio of 25 %: 75 % dhal: bread crumbs.

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Development of Fish Soup Cube using Yellow Fin Tuna Off-Cuts

T.K.R.N. Thalpawila, T. Nadeeka, S.C. Jayamanne
Uva Wellassa University, Badulla, Sri Lanka

and

S.W.N. Thushari
Global Sea Food (pvt) Ltd, Perawalawatta, Badalgama, Sri Lanka

Introduction

Fish are principal source of protein for world population and play a vital role in meeting basic nutritional and livelihood needs. Fish products are comparable to meat and dairy products in nutritional quality. Today even more people turn to fish as healthy alternative to red meat.

Sri Lanka has a large potential for marine fish production as it is surrounded by an Exclusive Economic oceanic area. A recent study has showed that average recovery percentage of expensive cuts of yellow fin tuna (*Thunnus albacares*) from a medium scale processing factory is approximately 50%. The remaining inexpensive off cuts has low market value. Tuna trimmings can be purchased at Rs. 200.00 per kg. The profit margin of food processing companies can be increased while converting these off cuts into value added products.

Fish soup cubes are now an established item on the world food market but not available in local market. A soup is a flavorful and nutritious liquid food served at the beginning of a meal or a snack. Instance soup cubes can save a good deal of time and effort. This study was conducted to develop fish soup cube using tuna off-cuts. The present study was carried out with an aim of producing a soup cube by adding value to low valued off cuts of yellow fin tuna.

Methodology

The experiment was carried out at the Global Sea Food (pvt) Ltd, Badalgama and the laboratory analysis were carried out at the Uva Wellassa University. Initially, a survey was carried out at the Global Sea Food (pvt) Ltd and usable off cuts, were identified considering wholesale prices and consumer prices. Subsequent to the preliminary survey selected off-cuts were analyzed for its nutritional quality, dry matter, ash content, crude protein content and crude fat content following AOAC standard methods (AOAC, 1995).

The preliminary trials were conducted first to find out the best combination of fish powder, salt and spices by changing ratios. These experiments were done in order to develop the solubility, texture and flavor of the soup cube. Once the satisfactory product was developed, the sensory analysis was carried out for the samples made using the final formula.

In order to find out the best recipe which gives better sensory qualities to the soup cube, another three samples (T1, T2 and T3) were prepared by changing fish powder and salt combination in small quantities in the finalized recipe (i.e. fish powder 20%: salt 30%, fish

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powder 22%: salt 28%, fish powder 25%:salt 25%, while keeping the other ingredients constant. Then, in order to select the best percentage combination of fish powder and salt sensory evaluation was carried out with 30 untrained panelists of Global Sea Food (pvt) Ltd. The sensory analysis was done using the Friedman nonparametric statistical test. Proximate analysis (AOAC, 1995) was conducted for all three treatments. Proximate analysis for the data measurement is a combination of crude protein, crude fiber, crude fat, moisture, total solid and ash. Shelf life of the fish soup cube was determined by testing pH and water holding capacity. For this, samples were taken at regular intervals weekly for one and half month storage period. Finally data were analyzed using MINITAB software.

Results and Discussion

Yellow fin tuna (*Thunnus albacares*) trimmings contain a 20 ppm level of histamine. The highest estimated median value and highest ranks were obtained for the treatment (T_3) having 20% of tuna trimmings and 30% of salt for; Appearance, Colour, Odour, Fish Taste, and Overall Acceptability. However, the score of T_3 for texture was low compared to the S_1, the control sample. S_1 gives highest scores for aroma, texture, solubility and overall acceptability.

Water Holding Capacity is basically related with the myofibrilla protein of the fish. WHC increased in the first six weeks. There were no differences between the pH values during the storage period. The fish soup cube samples were vacuum packed using an aluminum foil. Aluminum foil acts as a barrier for moisture and there are possibilities of reducing moisture penetration. Cubes are stored in a dry cool place. The proximate composition of the selected sample which was having 20% of tuna trimmings and 30% of salt; 3.267% of moisture, 16.483% of crude fat, 6.697% of crude protein, 32.067% of ash and 1.7.% of crude fiber.

The commercially available chicken cube showed higher scores for aroma, colour, texture, and solubility for its sensory attributes. Newly developed product shows highest score for fish taste.

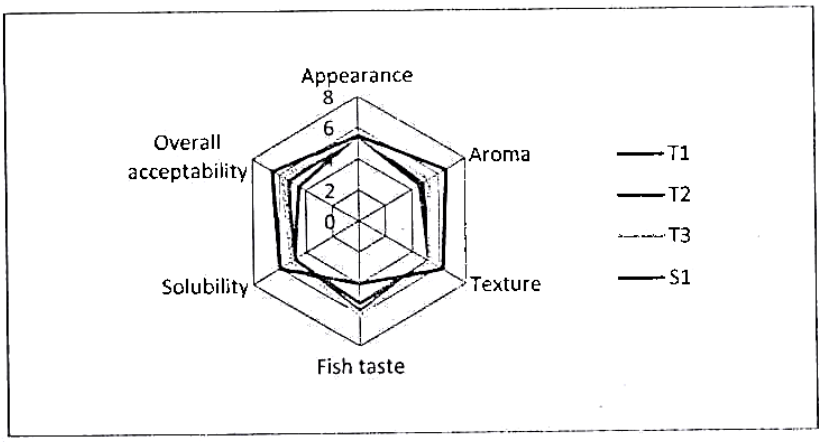

Figure 1. Web diagram for sensory evaluation

Conclusion

The best combination of tuna trimmings to salt was 20%: 30% on the weight basis. Shelf life of the tuna soup cube was more than 6 weeks with dry place respect to microbiological analysis and the physicochemical analysis. Cost for the final product with treatment T_3, 20% dry fish powder and 30% salt powder were SL Rs.4.10 per soup cube.

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Development of Ovo-Vege Fingers

H.M Kumarasinghe, R.M.H.Tharangani, N.P.P.Liyanage
Uva Wellassa University, Badulla, Sri Lanka

and

A.N. Lalantha
Keells Food Products PLC, Minuwangoda Road, Ekala, Ja-Ela, Sri Lanka

Introduction

As a developing country, most of the people in Sri Lanka are facing huge health hazards due to the sedentary life styles and improper nutritional habits. There is evidence that consumption of vegetables is important for human health, as they are good sources of dietary fibers, antioxidants, carotenoids, sulfur-containing compounds, water soluble vitamins and minerals (Steffen, 2009). Different studies have shown that antioxidants can play a key role in delaying elements and conditions that are associated with aging such as cancer, heart disease, decreased immune function, and visual and cognitive impairment (Tapsell *et al*, 2006). Therefore, this research was carried out to develop a vegetable based finger by incorporating egg white powder as a solution for various health effects occurred due to the consumption of convenient processed meat products.

Methodology

The current study was carried out at Keells food products PLC (KFPL), Ekala, Ja-ela. Laboratory analysis was done at KFPL and Uva Wellassa University laboratories. Four experimental trials with different treatments were conducted during this study. In trial I, proper combination of egg white powder and emulsion quantity was evaluated on the textural basis. Trial II was carried out to find out the appropriate spice combination suitable for the product. In trial III, jackfruit to carrot combination was evaluated and trial IV was done in order to find the best overall acceptability and finally three treatments were prepared and evaluated on sensory, chemical and microbiological basis. The sensory evaluation was done using 15 trained panelists twice at weekly intervals. In chemical analysis, proximate composition was determined for moisture content, crude fat, total solid, crude protein, ash and for organic non fat content. pH value and Water holding capacity were evaluated in weekly intervals for four weeks and microbiological analysis was done for *Escherichia coli*, *Salmonella*, *Staphylococcus aureus* and for Total Plate Count (TPC).The sensory data were analyzed using non-parametric procedure, according to the Friedman test using SAS (SAS Institute Inc., 2000) software programme. Complete Randomized Design (CRD) was conducted and data obtained from chemical and microbiological tests were analyzed using analysis of variance (ANOVA) using the General Linear Model (GLM) procedure of SAS (SAS Institute Inc., 2000). Significant means of treatments were separated using the Least Significant Difference ($P< 0.05$) test (LSD).

Results and Discussion

According to the sensory evaluation, the formulation with 25% of egg white powder and 75% of emulsion (T1) has given a desirable texture and selected in trial I. In trial II, Chinese finger formulation (T2) was selected due to sweet and hot flavor.

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In trial III, the treatment consisted with 60% of jackfruit to 40% of carrot (T3) was selected due to better mouth feel and proper toughness.

In the first sensory evaluation of T1, T2 and T3, there was a significant difference ($P<0.05$) among three samples regarding color, texture and spiciness and the T1 was selected as the best product. In the second sensory evaluation, there was a significant difference ($P<0.05$) between three samples regarding color, spiciness, texture and overall acceptability yet the mean scores for the all sensory characters were reduced. Therefore, during the frozen storage, overall acceptability of the products was altered considerably.

Table 1 Proximate composition and keeping quality characters of ovo-vege fingers

Parameter (Values during Storage at -18 ° C)	Treatments		
	T1	T2	T3
Proximate composition (%)			
Moisture	54.52	59.32	51.90
Total solid content	45.48	40.68	48.10
Crude fat	17.22	12.02	12.26
Ash	2.93	2.60	3.03
Crude protein	18.31	22.48	25.31
Organic non fat	25.33	26.06	32.81
pH			
1st week	7.85	7.42	7.40
2nd week	7.72	7.51	7.56
3rd week	7.86	7.39	7.38
4th week	7.75	7.25	7.31
Water Holding Capacity			
1st week	43.59	44.63	41.65
2nd week	42.90	43.58	41.36
3rd week	42.40	43.10	40.85
4th week	41.33	42.48	38.52

As indicated by the Table.1, the highest moisture content was observed inT2 followed by T1 and T3. That could be due to low content of egg white present in T2. Egg white needs a considerable amount of water to break the hardness of the product. Highest protein content was observed in T3 and that could be due to the high levels of isolated soy protein and egg white present in the formulation. Furthermore, highest crude fat content was observed in T1

followed by T3 and T2, since the crude fat content has increased with the increase of the vegetable oil content of the emulsion.

The pH values of three samples showed a slight elevation and thereafter gradual reduction. This situation can occur due to chemical degradation by food enzymes, converting food enzymes into lactic acid or chemical degradation by microbes or combination of these three incidences. Commonly the water holding capacity is reduced with the reduction of pH. The water retention power in vegetables is lower than in meat. Therefore, the reduction of water holding capacity in this vegetable based finger has to be solved.

TPC in the samples complied with the requirement of Sri Lankan Standard (SLS). Microbiological results indicated that TPC and *Staphylococcus aureus*have fulfilled those requirements during frozen storage.

Conclusion

Ovo-vege finger formulation having 7.7 % egg white powder was the best formulation having better sensory, nutritional and keeping quality characters.

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Optimization of Available Agar Processing Methodologies of *Gracilaria Verrucosa* in Kinniya

M. Yalinee, S.C.Jayamanne
Uva Wellassa University, Badulla, Sri Lanka

and

V. Pahalawattaarachchi
National Aquatic Resources, Research and Development Agency, Crow Island, Mattakkuliya, Sri lanka

Introduction

Seaweeds in Sri Lanka are mainly utilized for the production of commercially important products like agar-agar and alginic acid. Agar is commercially produced from *Gracilaria* and *Gelidium* species (Durairamam. 1962). but the gel strength is very low. This is mainly due to the processing technologies adopted and it is necessary to optimize the processing technologies to produce Agar with higher gel strength. In the present study, attempts were made to produce Agar with higher gel strength and higher yield using the species, *Gracilaria verucosa.*

Methodology

Raw seaweeds were collected from Kinniya Sea in Trincomalee District and were washed thoroughly to remove unwanted algae. The seaweed is air dried until the moisture content is less than 20% and washed again and sun dried in the open air. Samples were separated into three groups; A,B and C and dried for different time periods such as 2 days, 3 days and 4 days respectively. All foreign materials in dried seaweed were removed.

First, the samples were subjected to alkali treatment by placing 20 g each of seaweeds in three different concentrations of NaOH 4.5%, 5% and 5.5% and boiled at 85 ^{0}C for 1.5 hrs. Three replicates of three samples were used for the experiment. The NaOH concentration that gives best yield was selected for further processing. The samples were washed thoroughly with tap water until residues of NaOH is completely removed and were soaked in three different concentrations (0.5%, 1% and 1.5%) of H_2SO_4 acid for 1.5 hrs . Then samples were washed thoroughly in tap water then soaked in fresh water overnight to eliminate the acid completely. Next day the samples were boiled at 85 ^{0}C with 1:20 ratio of distilled water stirring slightly.

The gelled seaweeds were kept at 20 ^{0}C for 15 hrs and the gel strength was measured. Ten replicates were used for each sample and the force required to break a 1 cm^2 piece of gel was considered as the gel strength. The solidified agar was cut into strips and kept in the freezer at -35^{0}C for 24 hrs, then allowed to thaw in the room temperature and the gel yield was measured using a balance (Sartorius) with precision of 0.0001 g. Gel yield was taken as a percentage of initial sample (20 g). Finally, 1.5% agar solution was prepared by boiling agar in distilled water for 30 minutes and gel pH was measured using an electronic pH meter.

The data were analyzed using two-way ANOVA incorporated in MINITAB 14 software.

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Results and discussion

It was revealed that 5% NaOH solution gives the better yield irrespective of initial drying time ($p<0.05$) and the samples (A,B and C) were subjected to this concentration prior to processed by acid (Figure 1). The best concentration of H_2SO_4 for soaking is found to be 1% (Figure 2). The pH of agar ranged from 5.60 – 6.50 and gel strength varied from 94± 2 gcm^{-2} to 108±2 gcm^{-2}.

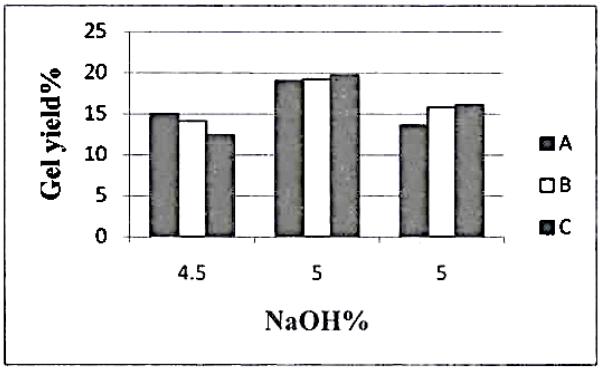

Figure 1: Gel yield obtained using sea weeds dried for A-2 days, B-3 days and C-4 days

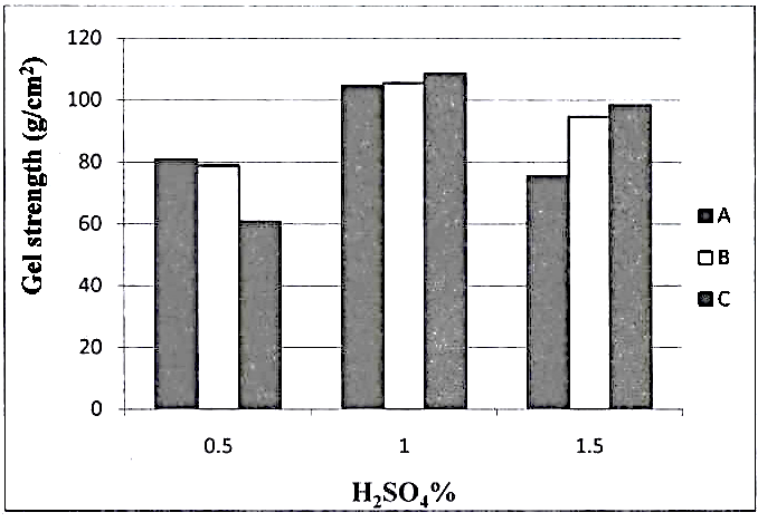

Figure 2: Gel strength (g/cm_2) of agar against concentration of H_2SO_4.

Highest yield of agar (19.7%) was obtained from the sample C (dried for 4 days) and lowest yield was obtained from sample A dried for 2 days). The yield obtained by the commercial producers usually lie within the range of 10%-25% (Hiroshi Tsukakoshi,

pers.com.) and the findings of this study is comparable with the findings of the commercial producers.

Conclusion

The higher gel strength and a gel yield can be obtain by treating seaweeds with 5% NaOH and 1% H_2SO_4. It is also evident that the drying time has an effect on the strength and yield of the final product. *Gracilaria verrucosa* can be utilized for producing Agar in Sri Lanka.

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Development of Fish Glue using Skin of Yellow fin tuna (*Thunnus albacares)* and Mahi-mahi (*Coryphaenidae hippurus)* and Characterization of Glue Properties

U.D.P. Manjula, S.C. Jayamanne, Thushari Nadeeka
Uva Wellasa Uniiversity, Badulla, Sri Lanka

and

Mahinda Malawige
Global Sea Foods (Pvt) Ltd, Badalgama, Sri Lanka

Introduction

Fish glue is made out of fish skin and is a special type of glue which differs from other animal glue due to their specific glue properties. It remains as a liquid in room temperature and has a higher open time, and very sticky (Shepherd, 2009). Fish glue is usually made from head bones, skin and fins of the cold water marine fish. Characteristics of the final glue product depends on the raw material selected (Norland,, 1990). Recognition of the limited biological resources and increasing environmental pollution has emphasized the value-addition using under-utilized fish and the by-products from the fish industry (Geurard *et al.* 2002). Dorsal skin of Yellow fin tuna (*Thunnus albacares*) is removed during tuna processing and can be used as a source of fish collagen.

The main objective of this study was to find out the best quality fish glue using fish skin of the yellow fin tuna and Mahi-mahi (*Coryphaenidae hippurus)*, and to identify the best and cheapest processing method for extraction of fish glue from yellow fin tuna and Mahi-mahi fish skin.

Methodology

The moisture content (Oven drying procedure), ash content, crude protein and fat content (using ether extraction) of tuna fish skin and Mahi mahi fish skin and glue were analyzed according to the AOAC standard methods.

Gelatin was prepared by acid extraction method. Cleaned tuna skin and Mahi mahi skin were treated at different solutions with known concentrations. The tuna and Mahi mahi skin were first washed in water separately at 23 °C and incubated twice in different concentrations of NaOH solution (0.1%, 0.2%, 0.4% w/v) for a period of different soaking times (for tuna, 18 hours and 24 hours and for Mahi mahi 1 hour, 3 hours). Then the skins were washed thoroughly with tap water and two successive acid incubations were performed using dilute HCl acid (0.1%, 0.2%, 0.4%v/v). Incubated time for tuna was 12 hours, 24 hours and for Mahi mahi 1 hour and 3 hours. The acid solution was drained and the sample was washed with running tap water for 1 hour and weighted the final skin sample. A gelatin extraction was performed by gentle stirring in open pan at 55-60 °C (8 hours for tuna and 6 hours for Mahi mahi). Solubilized gelatine was separated from residual skin fragments by filtering through a muslin cloth. The gelatine solution was boiled at 90 °C for 5-6 hours in an open pan to evaporate water to concentrate the glue sample. Finally a preservative (wintergreen oil) was added and bottled glue samples were kept in the refrigerator at chilled temperature -12 °C.

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Results and Discussion

Moisture content of the Yellow fin tuna and Mahi-mahi were 39.1% and 33.8% respectively. According to Cho *et al.* (2005) the dorsal skin of Yellow fin tuna has 56.1% moisture, 6.8% crude fat, 1.0% of crude ash and 33.6% of crude protein. The Mahi-mahi skin contained 46.73% of crude protein, 5.83%, of crude fat and 6.7% crude ash.

The acid and alkaline concentration of the solution used for pretreatment has great influence on the extraction of collagen from fish skin. This study showed that at the 0.4% acid and alkaline concentrations, considerable swelling and loss of collagen was experienced during 24 hours of soaking time compared to 18 hours.

Since Yellow fin tuna skin has considerable thickness than Mahi mahi skin, with the same alkaline and acid concentration significant changes in swelling of Mahi mahi skin was observed. Therefore, the soaking time for Mahi mahi skin was limited to 1- 3 hrs.

The mild alkaline treatment liberates all of the volatile bases which are the causative agents of the characteristic fish gelatin odour. In this study no fish odour in extracted glue was experienced due to the mild alkaline treatment followed by acid treatment.

The higher yield of gelatin and glue were recorded at 0.2% acid and alkaline solution for 24 hours soaking time and next at 0.2% acid and alkaline for 18 hours soaking time. For Mahi mahi 60% yield was experienced at 0.1% acid and alkaline concentration for one hour soaking time.

The chemical composition of gelatin extracted from yellow fin tuna and Mahi-mahi is with the standard fish glue is given in Table 1.

Table 1. The chemical and physical composition of yellow fin tuna and Mahi-mahi fish glue

Quality factors	Tuna Fish Glue	Mahi-mahi Fish Glue	Standard fish glue (Kremer)
Moisture content (%)	76.32%	78.50%	55%
Solid content (%)	23.68%	21.5%	45%
Ash (%)	0.81%	2.1%	Less than 0.1%
pH	5.06 -5.30	4.17- 4.40	4-6
Bonding power (after 30 minutes)	0.5 kg- 2.5 kg	0.1 kg -0.8 kg	-
Open time (hours)	1-3	4-5	1.5- 2
Time to tack (minutes)	1-3	4- 5	1
Melting point	20-22 ^{0}C	21-22 ^{0}C	5-10 ^{0}C
Color	Dark brown	Yellowish green	Light caramel

The concentration of the NaOH and HCl had a significant effect on extraction yield and open time. Other responses such as time to tack, melting temperature, colour were not significant. The best tuna glue sample was obtained at the concentration of 0.2% NaOH, with a soaking time of 24 hours, extraction temperature 55 °C and extraction time 8 hours ($P<0.05$). The best Mahi mahi fish glue sample was obtained at the concentration of 0.2%

NaOH, with a soaking time of 3 hours, extraction temperature 60 °C and extraction time 6 hours ($P<0.05$).

Conclusion

Yellow fin tuna and Mahi-mahi skin can be used as good sources for gelatin extraction and glue preparation using acid extraction method.

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Development of a Molded Sherbet Bar on a Stick with Frozen Yoghurt Core and lime (*Citrus aurantifolia*) Shell

Y. G. C. Indika[1], D. C. Mudannayake[1], A. M. N. L. N. Abeysinghe[1], J. K. Vidanaarachchi[2] and D. A. M. Arsecularatne[3]

[1]Uva Wellassa University, Sri Lanka
[2]Department of Animal Science, University of Peradeniya, Sri Lanka
[3]Ceylon Cold Stores PLC, Kaduwela, Sri Lanka

Aim of this study was to add value to conventional ice cream by developing molded sherbet bar on a stick with frozen yoghurt core and lime (*Citrus aurantifolia*) shell with higher sensory attributes and higher keeping quality. Best percentages of lime juice and gelatin for lime pulp was selected by changing the lime juice and gelatin levels as 10%, 15%, 20% and 0.5%, 1%, 1.5% respectively. The best percentages of sugar and overrun for frozen yoghurt was selected by changing sugar and overrun level as 10%, 12% and 60%, 70% respectively. Sensory evaluations were done by 15 trained panelists using five point hedonic scale. The final product was analyzed for titratabale acidity, pH, fat, protein, ash, total solids and compared with commercial faluda magic ice cream (reference sample). Shelf life determination was done by analyzing aerobic plate count, *E. coli* & coliform, yeast & mould, pH and titratable acidity analysis. Sensory data were analyzed by Friedman non parametric statistical method. Overall acceptability was highest($P<0.05$) in 15% (w/w) lime juice and 1.5% (w/w) gelatin added lime pulp and 12% (w/w) sugar and 60% (v/v) overrun added frozen yoghurt. Titratabale acidity and pH was not significant between final product and reference sample. According to the results, best lime juice and gelatin percentages for lime pulp were found as 15% (w/w) and 1.5% (w/w) respectively, while best percentage of sugar and overrun for frozen yoghurt were selected as 12% (w/w) and 60% (v/v) respectively. The shelf life of final product was equivalent to the reference product under frozen condition (-18 °C). The physicochemical analysis showed that final product consist of 0.21 titratabale acidity, 4.01 pH, 3.5% fat, 3.47% protein, 1.41% ash and 36.23% total solids. According to the results, final product complies with the SLS specification for ice cream.

Key words: Molded, Sherbet, Frozen, Yoghurt, Lime, Gelatin

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Development of Buttermilk Pudding Incorporating Skim Milk Powder, Condensed Coconut (*Cocos nucifera*) Milk and Kitul *(Caryota urens)* Treacle

I. M. V. E. Illankoon[1], D. C. Mudannayake[1], A. M. N. L. Abeysinghe[1], M. P. K. Jayarathne[2] and K. F. S. T. Silva[3]

[1]Uva Wellassa University, Sri Lanka
[2]Milk Industries of Lanka Company Ltd., Colombo, Sri Lanka
[3]Department of Animal Science, University of Peradeniya, Sri Lanka

Buttermilk is the major byproduct of butter industry. Lack of utilization as a food, shorter shelf life and low total solids content are the three major limitations associated with buttermilk. Few studies have been conducted on improving the utilization of buttermilk as dessert. Aim of this study is to add value to buttermilk by developing buttermilk pudding incorporating skim milk powder, condensed coconut (*Cocos nucifera*) milk and kitul *(Caryota urens)* treacle. Sensory evaluations were conducted to select the best percentages of skim milk powder, condensed coconut milk, kitul treacle and gelatin for buttermilk pudding. Skim milk powder, condensed coconut milk and kitul treacle levels were changed as 10% (w/w), 20% (w/w), 30% (w/w) and gelatin levels were changed as 1% (w/w), 2% (w/w) and 3% (w/w). The selected samples were analyzed for shelf life during day 1, 3, 7, 8, 10 and 12. Shelf life determination was done by analyzing coliform, yeast and mould, total colony count, pH and organoleptic qualities. Sensory evaluations were done by 30 untrained panelists to select the best percentage of skim milk powder, condensed coconut milk, kitul treacle and gelatin. Sensory data were analyzed by Freedman non parametric statistical method and pH, coliform, yeast and mould, total colony count were analyzed by correlation test. Overall acceptability was highest ($P<0.05$) in 20% (w/w) skim milk powder, 20% (w/w) condensed coconut milk, 20% (w/w) kitul treacle and 2% (w/w) gelatin added buttermilk pudding. Yeast, moulds and total colony count were increased ($P<0.05$) and pH decreased ($P<0.05$) after 10 days at 4 °C. According to the results buttermilk pudding incorporated with 20% (w/w) skim milk powder, 20% (w/w) condensed coconut milk, 20% (w/w) kitul treacle and 2% (w/w) gelatin (Percentages were calculated by weight of buttermilk) has been selected as the best formula with highest sensory attributes. Buttermilk pudding can be kept under refrigeration condition (4 °C) for 10 days without any quality deterioration.

Key words: Buttermilk, Pudding

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Development of Value Added Stirred Yoghurt Rippled with Cooking Chocolate Syrup

M. K. Ranasinghe[1], D. C. Mudannayake[1], A. M. N. L. Abeysinghe[1], L. Rupasinghe[2] and J. K. Vidanarachchi[3]

[1]Uva Wellassa University,Badulla, Sri Lanka
[2]Milco Pvt. Ltd, Naranhenpita, Sri Lanka
[3]Department of Animal Science, Faculty of Agriculture, University of Peradeniya,Sri Lanka

Developing a yoghurt incorporating cooking chocolate syrup is attempted with an aim of adding value to conventional yoghurt by increasing the organoleptic profile of the product. The composition of the conventional stirred yoghurts were modified slightly by varying gelatin percentages as 0.5%(w/w), 1.0%(w/w) and 1.5% (w/w). Best gelatin percentage was selected by sensory evaluation using 07 trained panelists. Stirred yoghurts prepared with selected gelatin percentage were rippled with 6.5 ml of chocolate syrup of three concentrations, 40%, 50% and 60% (percentage by weight). Chocolate incorporated stirred yoghurts were evaluated by using 30 untrained panelists with 5 point hedonic scale to assess sensory attributes such as, colour, appearance, chocolate flavour, sweetness and overall acceptability. Sensory data were analyzed by friedman non-parametric statistical method while titratable acidity and pH were analyzed by one-sample t-test in MINITAB 14. Shelf life determination was done by analyzing titratable acidity, pH, yeasts and moulds, total colony count (TCC), coliforms and *Escherichia coli* at two days intervals for 15 days comparing with the plain stirred yoghurt which was chosen as the control. Stirred yoghurt prepared with 50% chocolate syrup concentration showed higher ($P<0.05$) preference with all sensory attributes except appearance. The pH and titratable acidity of the above concentration was significantly higher ($P<0.05$) compared to the control at day 3. Coliforms, *Escherichia coli* and Yeast and mould counts were in compliance with specifications in Sri Lankan Standards for the set yoghurt during 10 days of refrigerated storage. Based on the results it can be concluded that stirred yoghurt rippled with chocolate syrup prepared with 0.5% gelatin and 50% chocolate syrup concentration has the highest sensory attributes with 09 days of shelf life at 4 ^{0}C temperature.

Key Words; Stirred yoghurt, Gelatin, Chocolate Syrup

Livestock Farm Development and Management

Characterization of Goat Production Systems in Badulla District of Sri Lanka

H.M.N.P. Nandasena, J.M.D.R. Jayawardana and M.S. Kurukulasuriya

Department of Animal Science, Uva Wellassa University, Badulla, Sri Lanka.

Goat farming in Sri Lanka has a great potential for improvements, especially in rural economies, since it can be operated with low input levels. Badulla district is considered as a rural area where agricultural activities are predominant. However, the available information on goat farming in Badulla is minimal, limiting the opportunities for further development. Hence, the objective of this study was to characterize the goat production systems in Badulla district. A survey was conducted using 320 goat famers in 15 divisional secretariats of Badulla district using stratified and simple random sampling techniques. A pre-tested structured questionnaire was used to collect data on farmers' general information, herd characteristics, management practices and constraints of farmers. Data were analyzed using Minitab 17 statistical software. The results indicated that goat farming is more popular among Tamil and Muslim communities. Out of total study sample, 76.9% were Tamil and 19.7% were Muslim. Majority of goat farmers (80.6%) had only the primary education. Almost all farmers (99.7%) in the area considered goat farming as a secondary income source. In 91.9% goat farms, herd owner is a male although housewives and children helped in farming activities. Most of goat herds were indigenous (75.6 %) while 24.4% were Jamnapari crosses. The average herd size was 6.65 ±4.70. All farmers rear goats under semi-intensive management system. Although, cut and feed, tethering and free grazing were found as major roughages feeding systems, these can vary in different areas of Badulla according to the resource availability. Around 50.0% farmers used raised slatted floor houses. According to the farmers' perception, lack of goat breeds, less government support and less land availability were identified as main problems in goat farming in Badulla. Therefore, based on proper data, short-term and long-term development plans should be implemented for development of goat farming in Badulla.

Keywords: Goat, Production systems, Badulla, Indigenous, Jamnapari

Animal Welfare in Broiler Industry: From Farm to Processing Plant

H. G. N. Madumadavi[1], W.A.A.N Weerasuriya[2], J.M.D.R Jayawardana[1], H.K.T. Awanthika[1], Dinesh .D. Jayasena[1]

[1]*Department of Animal Science, Uva Wellassa University, Badulla 90000, Sri lanka*
[2]*Pussalla Meat Producers (Pvt) Ltd., Kosgama, Sri Lanka*

Animal welfare relates to the general health and well-being of animals. The world animal welfare can be divided in to two categories; 1) countries having specific strategies to prevent animal welfare abuses and 2) countries not having specific strategies to prevent animal welfare abuses. Sri Lanka might be included in to second category. The objective of this case study was to identify general welfare practices of a commercial broiler company from farm to processing plant. Separate pre-tested questionnaires were used to collect information from farmers, catching crew, drivers and unloading crew of the broiler company. According to results, 94% of the farmers practice the starvation period 8 hours before catching and 63% of farmers give water continuously until transportation. However, 31% of farmers do not receive training workshops to know about the good poultry farming practices including welfare practices. All the members in catching crew and unloading crew use the birds legs for catching. Average space given per bird by 99% farmers was 1.2 m^2. All drivers transport birds at 60-70 km/h^{-1} with good welfare practices. They transport animals humanely. The primary records showed a daily poultry mortality rate of 2 - 3% . The commercial broiler company where this study was conducted at practice good animal welfare practices from farm to processing plant.

Keywords: Animal welfare, Broilers, Transportation, Starvation, Mortality rate

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A Study on Variances in Sensory Properties and Meat Qualities of *Oreochromis niloticus* (L) with Their Sex, Size and Inhabiting Reservoir

W.D.S. Priyadarshani, N.P.P. Liyanage, Dinesh D. Jayasena, S.A. Kumar, H.K.T. Awanthika

Department of Animal Science, Uva Wellassa University, Badulla 90000, Sri Lanka

Nile tilapia *(Oreochromis niloticus)* is one of the commonly captured and highly preferred fish species in inland fisheries and also popularised as tastiest fish among the other freshwater fishes. However, there was a common belief among fisher communities as well as consumers that the taste of tilapia is varying from reservoir to reservoir. It is obvious that condition of the existing reservoir and available food items can affect quality and taste of the fish. Further, sensory qualities, ash and moisture content of fish flesh can be affected by age, sex, fat content, environmental factors and dietary ingredients. The present study aimed to determine the relationship of sensory qualities of Nile tilapia with sex, inhabiting reservoir and size of the fish. It also aimed to identify gut contents of fish samples collected. Male and female fishes from two size ranges were collected from three different reservoirs (Sorabora, Rathkinda, Nagadeepa) in Badulla district. First one third of the gut was immediately separated and preserved in 5% buffered formalin until subjected to gut content analysis. Fish samples were taken in to the Aquaculture laboratory of Uva Wellassa University and stored under -20 ^{0}C. Initially, moisture content, ash content, pH, cooking loss and water holding capacity of fish fillets were analysed. Parallelly, a sensory test was conducted using cooked tilapia flesh with 30 untrained panellists to identify the sensory properties i.e. taste, colour, appearance, odour, tenderness, juiciness, oiliness and overall acceptance. According to sensory evaluation, female fish in Sorabora reservoir with the size range of 300-500 g, recorded the highest score for overall acceptance. However, male fish collected from the same reservoir with the same size range obtained highest score for taste. Female fishes collected from Rathkinda reservoir in 300-500 g size range scored the lowest overall acceptance. Ash and moisture content of the fish samples collected showed significant difference ($p < 0.05$) with size and the inhabiting reservoir. Cooking loss showed a significant difference with inhabiting reservoir. Phytoplankton was identified as the dominant group present in the gut content of all the individuals analysed. Filamentous algae were the prominent organism in gut contents of fish samples collected from Sorabora reservoir and three identical zooplankton genera were also observed. However, further analysis is needed to evaluate the factors for variance in sensory and meat quality traits of fish samples.

Keywords: Fisheries, Fish flesh, Food science, Tilapia

Biodiversity: Oral Presentations

Evaluating Agro-biodiversity in Kandyan Homegardens in Different Land Use / Land Cover Change Categories in Kandy District

A.M.N.S.K. Abeysinghe[1], L.M.H.R. Alwis[1], R.M.C.W.M. Rathnayake[1], H.K. Kadupitiya[2]

[1]*Department of Export Agriculture, Uva Wellassa University, Badulla 90000, Sri Lanka*
[2]*Natural Resources Management Centre, Department of Agriculture, Peradeniya*

Kandyan Homegardens are multi-species traditional agro forestry system which provides food, nutrients, timber, medicine and many other services while conserving bio diversity. Highly intensified Land Use / Land Cover changes in Kandy district during the past few years cause a huge impact on biodiversity of Kandyan Homegardens. Hence, this study was carried out to assess the agro-biodiversity in the mid country wet zone of the Kandy district. Land Use / Land Cover change map prepared using Normalized Difference Vegetation Index change between Landsat images of year 2000 and 2015 was used for the study. Three Land Use / Land Cover change categories were identified as less changed, moderately changed and highly changed. Field investigations were carried out in 90 homegardens in Ambathenna, Pilimathalawa, and Gampola to assess the agro-biodiversity. Land Use / Land Cover change category which Kandyan Homegarden belonged to was identified using a Global Positioning System device. Land holding size in majority of homegardens was between 0.01 to 0.76 ha. Trees, root and tuber crops consisted of 88 species and 45 plant families were identified. Evaluations of species existence showed that number of species present in moderately changed area is 60 compared to 54 species in less changed area and 47 species in highly changed area. Furthermore, twenty seven species were perceived as threatened or lost from Kandyan Homegardens by the dwellers. Species Richness, Shannon-Weiner index and Simpson Diversity Index were used to evaluate the agro-biodiversity. Each LU / LC change category exhibited a wide range of richness due to different land holding sizes. Moderately changed areas have high average species richness (16.61) whereas Shannon-Weiner values for diversity are similar in less changed area (2.33) and moderately changed areas (2.34). Moreover, evenness of abundant species is higher in moderately changed area (0.85). Hence, results of the study suggests that agro-biodiversity in moderately changed area is high in mid country wet zone of Kandy District.

Keywords: Agro-biodiversity, Kandyan Homegardens, Land Use/Land Cover change

Biodiversity: Poster Presentations

Study on phenotypic variations and haemoparasites in village chicken in cascade and ovita agro-eco systems

C.S. Dissanayake[1], D.M.S. Munasinghe[2], L.G.S. Lokugappatti[2], M.S. Kurukulasuriya[3]

[1]*Department of Animal Science, Uva Wellassa University, Badulla 90000, Sri Lanka*
[2]*Department of Basic Veterinary Sciences, University of Peradeniya, Peradeniya, Sri Lanka*

Ancient Sri Lanka had a sustainable ecosystem where people maintained man environment relationship in a passive way to have balanced ecosystems while utilizing for agriculture. Village chicken is commonly reared in such ecosystems and is important in low-income families. Productivity of village chicken can significantly be reduced by Haemoparasitic infections. Objectives of this study was to classify village chicken phenotypes and to determine prevalence of heamoparasites of village chicken reared in two different agro-ecosystems of Sri Lanka. Thirteen farmers from Milleniya of Bandaragma in Kaluthara district (6.7144^o N, 79.9891^o E) representing Ovita agro-ecosystem and 12 farmers from Gamploa of Giribawa in Kurunagala distict (8.1156^o N, 80.1973^o E) representing Cascade agro-ecosystem were selected. A total of 54 randomly selected mature village chicken from each research site (RS) was included in the study. Both qualitative phenotypic data (plumage color, shank color, sex, comb types, comb size) and quantitative data (shank length, wing span, and body length) were collected from each bird following FAO guidelines. For determination of haemoparasite prevalence, 34 Leishman stained blood smears from each site were examined under the light microscope using standard references as the identification guide. All collected data were analyzed using Minitab 17 and significance of differences of phenotypic parameters between two sites were evaluated using t−test. The both RS mainly consisted with Normal village chicken phenotype (87% in Bandaragama & 91% in Giribawa). Further, 7% long legged and 7% crown chicken were identified in Bandaragama and Giribawa, respectively. There was no significant quantitative phenotypic difference of chicken within site ($P > 0.05$) though the difference is significant between 2 sites ($P < 0.05$). Shank length ($0.011 < 0.05$), Body length ($0.00 < 0.05$) and Wing span ($0.0004 < 0.05$) was higher in female Normal village chicken in Badaragama than the Giribawa. There was no significant difference between male village chicken in those two sites ($P > 0.05$). Many plumage color patterns were observed due to cross breeding. Most predominant comb type and shank color were single comb and yellow shank, respectively. Microfilaria is the only haemoparasite found in both sites and the prevalence of microfilaria in Badaragama and Giribawa are 26% and 17.64%, respectively. This could be due to resistance of village chicken to parasitic diseases in the research sites. In conclusion there was significant difference in phenotypic characters between female village chickens of the two sites.

Keywords: Haemoparasites, Village chicken, Agro eco systems, Phenotypic variations
Acknowledgement : Biodiversity for adaption to Climate Changes (BACC) project

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Performance Evaluation of Chicks, Obtained Through a Selective Breeding Programme to Introduce into Backyard Poultry Farming

S.M.C. Weerasinghe, N.M.N. Nambapana
Uva Wellassa University, Badulla, Sri Lanka

and

G. Gunawardene
Department of Animal Breeding, Veterinary Research Institute, Gannoruwa, Peradeniya, Sri Lanka

Introduction

Poultry production has increased rapidly and tremendously in the last two decades in Sri Lanka (Gamage *et al.*, 1993). The Department of Animal Production and Health (DAPH) – Government of Sri Lanka during the past decade through the Central Poultry Research Station (CPRS), Karandagolla, Kundasale has been distributing upgraded indigenous chicken among Backyard farmers.

Breeding Indigenous cockerels with Black shaver commercial layer hens is the breeding program practiced presently (2011) at CPRS to upgrade the Indigenous chicken. Performance evaluations of resulting chicks obtained through a selective breeding of Black Shaver hens with Indigenous cockerels is the first step of the project. Program was carried out at CPRS, Karandagolla.

Methodology

Hundred thirty eight breeder birds at age of twelve months were randomly selected for the study. Twenty hens and three cockerels were included in each mating group. Three treatment mating groups; a. Black Shaver hens with indigenous cockerels, b. Black shaver hens with Black shaver Cockerels and c. Indigenous hens with indigenous cockerels were maintained in constant conditions. The latter two treatments were regarded as Control 1 and Control 2. A replicate was maintained for each mating group.

Separately collected, numbered, cleaned and fumigated eggs were set into brooder once per week. Eggs were candled on 18th day and transferred into Hatcher machine. Chicks were taken out on 21st day. Wing band was given to each bird for identification.

Data of eggs, birth weights, weekly body weights, average feed intake per day and mortality were recorded in treatments and two control groups including replicates.

Data were analyzed using Microsoft office excel and SPSS 16.0 analytical software. Central tendency, Dispersion, One way Analysis of Variance tests were conducted for the collected data.

Results and discussion

According to the eggs data analysis results at the 5% level of significance, there were a significantly lower number of fertile eggs ($p<0.01$) in Indigenous group than treatment group eggs. There were significantly higher number of good chicks in black shaver group than treatment ($p<0.01$) and indigenous groups ($p<0.01$).

Feed intake of treatment chicks is significantly lower ($p<0.05$) in treatment chicks' than black shaver chicks.

There were significantly higher mortality ($p<0.01$) of treatment chicks' than black shaver chicks and significantly lower ($p<0.01$) mortality of treatment chicks' than indigenous chicks.

Conclusions

Considering all the results of study, the birth weights and weekly body weights of treatment chicks' were almost similar to that of black shaver and indigenous chickens. Feed intakes of treatment chicks' were lower than black shaver chicks.

Treatment / Resulting chicks of selectively bred group had the better performance than indigenous chicks when considering most of the evaluated factors. Black shaver chicks had the best performance out of all three groups. Overall performance of treatment chicks' were in between the black shaver chicks and indigenous chicks.

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Nutrition and Feed Development

Effect of Storage Time on the Physical Changes and Proximate Composition of Feed Ingredients Stored Under Room Temperature

R.M.S.P. Rathnayaka and N.M.N. Nambapana

Department of Animal Science, Uva Wellassa University, Badulla, Sri Lanka

Quality of the feed ingredient is one of the most important factor considered by feed processing industries. Feed ingredients are comprised with many nutrients and the nutrient availability varies due to different reasons. This study was conducted to evaluate the effect of storage time on the physical changes and proximate composition of feed ingredients stored under room temperature. Newly arrived maize, rice polish and coconut poonac samples were collected, packed using woven polypropylene bags and stored for two months under room temperature. Physical changes and proximate composition of samples were checked at 15-day time intervals and data were analyzed by Kruskal–Wallis test and one-way analysis variance using Minitab 17 software respectively. There were physical changes in rice polish and coconut poonac ($p<0.05$) while there were no physical changes observed in maize during storage period ($p>0.05$) and rice polish was infestation by insects after 45 days of storage. During storage period crude fat, crude protein, ash and fiber contents of rice polish were decreased by 65.25%, 20.89%, 4.69% and 7.35% respectively ($p<0.05$). Crude fat, crude protein, ash and fiber content of coconut poonac were decreased by 19.71%, 23.05%, 7.62% and 8.46% respectively($p<0.05$). Except moisture, other macro nutrients of maize did not change with the storage time ($p>0.05$). Therefore, it can be concluded; that proximate composition of coconut poonac and rice polish were decreased considerably during the storage under room temperature. Further, changes of physical characteristics of feed ingredients are not sufficient to determine the quality of stored feed ingredients.

Keywords: Feed ingredients, Physical changes, Proximate composition, Room temperature, Storage time

Effect of Soy Bean Meal and CO-4 Grasses on Milk Production of Milking Cows in Mid Lactation Period

A.S. Kodithuwakku[1], N.M.N. Nambapana[1], K.K.T.N. Ranaweera[1] and R.M.S. Gunathilaka[2]

[1]Department of Animal Science, Uva wellassa University, Badulla, Sri Lanka
[2]Pelwatte Dairy Industry Ltd, Private Mail Bag, Buttala, Sri Lanka

Dairy industry in Sri Lanka is the main sub sector of livestock development at present. Milk yield per cow and the cost of feed to produce milk have greatest influence for profitability of a dairy operation. This study was conducted to determine the effect of soy bean meal (SBM) and CO-4 grasses on milk production of milking cows (3-5 years old) in mid lactation period. A total of twelve dairy cows were randomly assigned into three dietary treatments. Each treatment comprised two blocks according to stage of lactation and two cows were included in each block. Mid lactation stage milking cows were selected to three dietary treatments and each treatment comprised with 4 replicates. The control group (T_0) of milking cows was fed concentrate (existing) feed and CO-3 grasses. The cows in T_1 treatment were treated with concentrate feed enriched with SBM and CO-3 grasses and cows in T_2 treatment were fed concentrate feed enriched with SBM and CO-4 grasses. Morning and evening milk yields were measured and milk quality (fat and SNF) was checked weekly. All the collected data were analyzed using repeated measures ANOVA and t-paired test. There were no significant differences in average milk yield of cows between T_0 and T_1, however the average milk yield of cows in T_2 has increased significantly ($p<0.05$). The highest fat value (4.7%) and SNF value (9.37) were recorded from the milk collected from cows in T_2. In conclusion, the dietary supplementation of SBM and CO-4 grasses included diet had better effects on milk yield and quality of the milk.

Keywords: Soy bean meal, CO-4, Milk yield, Milk quality

Evaluation of Growth Performance and Nutritional Composition of Three Fodder Crops (Maize, Sugargraze and Nutrifeed) Cultivated in Omanthai, Northern Region of Sri Lanka

M.G.I.U. Meddegoda[1], J.M.P. Jayasinghe[1], K.K.T.N Ranaweera[1] and G.M.P.J. Bandara[2]

[1] Department of Animal Science, Uva Wellassa University, Badulla, Sri Lanka
[2]Agro Industries LTD, Prima Group, Seeduwa, Sri Lanka

Feeding high quality forages is a vital factor to get high production from dairy cattle. However, rainfall is a key limiting factor in Northern region of Sri Lanka resulting lower forage production and higher variations. This field experiment was conducted in Omanthai, Vavuniya (8.8908°N, 80.507°E, annual rainfall 1434 mm, average temperature 27.4°C) during Maha Season (October–December 2018) to study the growth performances and nutritional composition of three fodder crops and identify the most suitable crop variety to the region. Three fodder varieties, Sugargraze (*Sorghum bicolor*), Maize 984 (Zea *maize*) and Nutrifeed/Pearl millet (*Pennisetum glaucum*) were tested in a Completely Randomized Design with 3 replicates. A total of 10 randomly selected plants from each plot were weekly measured for growth parameters (plant height, number of leaves, leaf length and number of tillers) up to 60th days of planting for sugargraze and maize, and up to 45 days for Nutrifeed. Harvested fodders were measured for fresh matter (FM) and dry matter (DM) yield and subjected to the proximate analysis (crude protein, and total ash content). The results revealed that the Sugargraze (*Sorghum bicolor*) showed a higher ($p<0.05$) plant height (252.18±4.5cm) followed by Maize 984 (241.29±3.0cm). However, Maize 984 (Zea *maize*) resulted the highest FM (90.67±0.15 t ha^{-1} cut^{-1}) and DM (26.76±1.39 t ha^{-1} cut^{-1}) contents ($p<0.05$). Nutrifeed/Pearl millet (*Pennisetum glaucum*) was significantly higher in number of leaves (60.00±1.66) and tillers (6.07±0.15) ($p<0.05$) but lowest in FM (30.13±1.69 t ha^{-1} cut^{-1}) and DM (18.76±0.39 t ha^{-1} cut^{-1}). The highest crude protein content was recorded in Nutrifeed (12.65%) in comparison of Maize (6.33%) and Sugargraze (10.16%). Nutrifeed had the highest total ash (10.43%). These findings revealed that maize performed better in growth performances, however nutritive value was high in Nutrifeed cultivated in Omanthai, Vavuniya, Northern region under low rainfall.

Keywords: Growth performance, Maize, Nutrifeed, Nutritional composition, Sugergraze

Determine The Effect of Fermented Soybean Meal Supplementation into A Diet with or Without Fish Meal On Growth Performance and Meat Quality of Broiler Chicken

S.K.T. Premathilaka[1], N.M.N. Nambapana[1], Li Ang[2] and D.D. Jayasena[1]

[1]Department of Animal Science, Uva Wellassa University, Badulla, Sri Lanka
[2]New Hope Lanka Ltd, Kuruduwatta road, Ekala, Ja-Ela 11350, Sri Lanka

Effective feed formulation is considered as an essential element for broiler growth performance. Fermented soybean meal (FSBM) is a plant derived protein source which comprises with higher nutritional value. Thus, this research was conducted to determine the effect of FSBM supplementation into broiler diet with or without fish meal (FM) on performance and meat quality of broiler chickens. Two hundred fourty day old broiler chicks were randomly assigned into four dietary treatments and each treatment comprised with six replicates. The control group (T_0) received 4% (w/w) of FM and 0% (w/w) of FSBM for booster, starter and finisher diets, respectively. Broilers fed other experimental diets were; T_1 (3% w/w FM, 2% w/w FSBM), T_2 (2% w/w FM, 3% w/w FSBM) and T_3 (0% w/w FM, 4% w/w FSBM) in booster, starter, and finisher diets, respectively. Body weights and feed intake were recorded during the experimental period. In addition, fecal samples were collected to evaluate Moisture, Ash, Nitrogen, Calcium and Phosphorous. In day 41, two birds that near to the mean body weight were slaughtered to measure the visceral organ weights, carcass weights, and, meat quality parameters in each replicate. There was no significant ($P>0.05$) difference on growth performance, meat quality parameters, carcass characteristics and relative organ weights of broilers fed different dietary treatments. The highest Calcium (3.55%) and Phosphorous (1.81%) percentages in feces were recorded from broilers fed T_1 while the lowest Calcium (2.27%) and Phosphorous (1.21%) percentages in feces were recorded from broilers fed T_3 ($P>0.05$).In conclusion, FM in broiler diets can be replaced by FSBM and there were no negative effects in both growth performances and meat quality of broiler chickens.

Keywords: Broiler chickens, Fermented soybean meal, Growth performance, Meat quality

Effect of the Pellet Size on Pellet Durability and Feed Conversion Ratio of Broiler Chicken

H.S. Madushani[1], N.M.N. Nambapana[1] and N.D. Andaraweera[2]

[1]*Department of Animal Science, Uva Wellassa University, Badulla, Sri Lanka*
[2]*Fortune Agro Industries (Pvt) Ltd, Wariyapola, Sri Lanka*

There are enough information reported, to determine the suitable pellet form and its' effect on feed conversion ratio for broilers, not for the pellet sizes. Hence, present study was conducted to determine the effectiveness of three different pellet sizes on feed conversion ratio (FCR) of broilers and pellet durability index (PDI) of broiler finisher feed. Keeping quality of broiler finisher feed was checked for two months under room temperature. A total of two hundred and twenty five 22-day old broiler chickens were randomly assigned into three dietary treatments. Each treatment comprised of three replicates and twenty five broiler chickens were included in each replicate. Broilers were randomly allocated to one of three experimental diets and fed for 14 days in a complete randomized design. The dietary treatments included two different pellet sizes and the existing pellet size as control group; T0 (0.5 cm), T1 (1.25 cm) and T2 (0.2 cm). Body weight and feed intake were recorded during the experiment period. Three sizes of pellets were stored for two months under the same conditions to check the keeping quality of the pellets. Under the proximate composition evaluation, crude protein, crude fat, crude fiber, moisture and ash content were evaluated. Data were analyzed by one way (weight gain, feed intake and FCR) and two way analysis (proximate composition analysis) of variance of Minitab 17 software. The feed intake, weight gain and the FCR of chicken were not affected ($p>0.05$) by dietary treatments. The PDI was not affected ($p>0.05$) by the treatments with time. In keeping quality analysis, there was no significance ($p>0.05$) difference of pellet sizes with time. In conclusion, there were no any effect of the pellet size on PDI and FCR of broiler chicken.

Keywords: Pellet size, Feed conversion ratio, Pellet durability, Broiler chicken

Development of Low Cost Mass Culture Media for *Spirulina platensis*

K.S.P. Munirathna, A.C.W.W.M.C.L.K. Coswatte and S.C. Jayamanne

Department of Animal Science, Uva Wellassa University, Badulla, Sri Lanka

Spirulina platensis is an algae popular as a food supplement with high protein content. The pure cultures of *Spirulina* are maintained using Zarrouk medium, which cannot be used for mass culture as the medium is highly expensive. The present study aims to develop a low cost mass culture media suitable for commercial scale culture of *S. platensis* in Sri Lanka. Three culture media [T1 (w/w)-$NaHCO_3$:73.68%, NaCl:8.77%, Urea :10.96%, Albert solution:4.38%, T2 (w/w)-$NaHCO_3$:75.4%, NaCl:7.18%, Muriate of Potash:4.39%, Triple Supper Phosphate:1.79%, Urea:11.22%, T3 (w/w) -Triple Supper Phosphate:0.95%, $NaNO_3$:7.18%, Muriate of Potash:4.96%, NaCl:47.91%, $MgSO_4$:0.71%, $CaCl_2$:0.19%, $NaHCO_3$:38.33%] were formulated by incorporating selected fertilizers and other cost-effective alternative chemicals, while Zarrouk medium was used as the control. Three media were tested in triplicates for growth performance of *Spirulina*. One-unit volume was used from a pure culture with 1100 cells ml^{-1} and inoculated in to all the treatments. Cultures were initiated in an axenic batch culture method in the formulated media and maintained under the illumination of 4000 lux and at 35°C temperature. The growth rate of culture was measured by counting the number of cells under light microscope and cell ratio was calculated. Data were collected once in three days for 15 days and data were statistically analyzed by one-way analysis of variance (ANOVA) Results revealed the significantly high numbers of cells (186.24±25.76 cells ml^{-1}) in T3 followed by control 123.21±3.10 cells ml^{-1}, T1 114.80±27.97 cells ml^{-1}, T2 96.92±3.69 cells ml^{-1} ($P<0.05$). Hence, T3 medium was identified as the most favorable media for the growth of *S. platensis*. The highest growth rate was also observed in T3 medium during the 15 days culture period. According to the cost analysis, T3 medium **was three times cheaper than the Zarrouk's medium and can be recommended for** initiating mass culture of *S. platensis* in Sri Lanka.

Keywords: *Spirulina platensis*, Growth, Zarrouk medium, Mass culture media

Comparative Study on Total Chlorophyll, Carotenoid, Fucoxanthin in Seaweeds *Ulva reticulata, Sargassum ilicifolium* and *Gracilaria multipartita* and Colour Enhancing Commercial Ornamental Fish Feeds

S.M.N.U. Samarakoon[1], M.P.K.S.K. De Silva[2], W.A.R.K. Senaarachchi[2] and N.P.P. Liyanage[1]

[1]*Department of Animal Science, Uva Wellassa University, Badulla, Sri Lanka*
[2]*Department of Zoology, University of Ruhuna, Matara, Sri Lanka*

Seaweeds are photosynthetic marine macro algae, contain various natural colour pigments. Considering high bioavailability and low cost of processing, this study aimed on evaluating the potential of using seaweeds as a feed additive for colour enhancement of ornamental fish compared to commercial colour enhancing ornamental fish feeds by assessing three types of pigments. Three algae species (green algae-*Ulva reticulata*, brown algae-*Sargassum ilicifolium* and red algae-*Gracilaria multipartita*) were collected from Dickwella area. Pigments were extracted into 10 ml of 99% acetone from sun-dried algae and from 3 types of commercial feeds having green, brown and red colours. Total chlorophyll, carotenoid and fucoxanthin content of seaweeds and commercial feeds were quantified using UV spectrophotometer. Non-normally distributed data were analyzed by Kruskal Wallis test in Minitab version 17 at 0.05 significant level. Highest total chlorophyll content was observed in *U. reticulata* (70.50±0.39 μg g^{-1}) & *S. ilicifolium* (59.53±4.34 μg g^{-1}) and it was significantly different from their respective colour feeds (green 4.57±1.63 μg g^{-1} and brown 7.69±5.56 μg g^{-1}). Similarly, *U. reticulata* and *S. ilicifolium* had significantly different carotenoid content (1.44±0.16, 2.11±0.07 μg g^{-1}) compared to their respective colour feeds (green 0.22±0.09 μg g^{-1} & brown 0.21±0.07 μg g^{-1}). Chlorophyll & carotenoid content had no significant difference between *G. multipartita* and its respective red colour feed. Fucoxanthin content was also higher in seaweeds (*U. reticulata* 2.12±0.89 μg g^{-1}, *S. ilicifolium* 4.69±3.05 μg g^{-1} and *G. multipartita* 1.52±0.82 μg g^{-1}) than three commercial feeds (green 1.82±1.81 μg g^{-1}, brown 0.53±0.33 μg g^{-1} & red 0.49±0.06 μg g^{-1}) with no significant difference. Results indicate that sun-dried seaweeds contained comparatively high level of pigments studied; the selected sea weeds may be taken as an effective feed additive for the colour enhancement of ornamental fish.

Keywords: Pigment extraction, Seaweeds, Ornamental feed, Chlorophyll, Carotenoid

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Suitability of Plant Based Ingredients: Rice Bran, Coconut Poonac and Maize as Binders for Quality Improvement of Fish Feed Additive Made from Autolyzed Shrimp Waste

J.M.S.K. Jayasundara[1], M.P.K.S.K. De Silva[2], W.A.R.K. Senaarachchi[2] and N.P.P. Liyanage[1]

[1]*Department of Animal Science, Uva Wellassa University, Passara Road, Badulla, Sri Lanka*
[2]*Department of Zoology, University of Ruhuna, Wellamadama, Matara, Sri Lanka*

Discarded shrimp shells, a good source of natural astaxanthin, proteins and lipids can be used as a feed additive to enhance colouration and growth of ornamental fish. Temperature-induced autolysis of shrimp waste breaks the chitin-protein bonds and releases these nutrients. Hydrolysate extracted by autolysis is sticky and perishable at room temperature (30 °C). The main Objective of this study was to improve quality and shelf life of shellfish waste extract using plant-based ingredients as binders. Shellfish waste (100 g) was subjected to thermal autolysis at 55 ^{0}C for 15 minutes with continuous stirring. Resultant Hydrolysate was mixed with powdered rice bran, coconut poonac and maize separately in different ratios of hydrolysate: plant ingredient (1:1, 1:2 and 1:3) each in triplicates. Protein and moisture content were determined in oven-dried samples. Samples at room temperature were checked for changes in physical properties (colour, stickiness, odour) and fungal formation (clotting) once a week for one-month period. Highest crude protein percentage was observed in samples of 1:1 hydrolysate: plant ingredient ratio (rice bran: 38.13±8.20%, coconut poonac: 47.83±3.75% and maize: 36.76±5.74%) with significant differences (P=0.002) of treatments among three binders. Protein content and stickiness reduced with increasing binder content. Rancid odour, colour change and clotting were minimal during this time period with highest binder content (1:3). Moisture percentage was significantly different (P<0.05) among samples of 1:1, 1:2 and 1:3 ratios and lowest (9.54±1.79) in samples with 1:2 ratio prepared using coconut poonac. Coconut poonac with highest protein and lowest moisture content is advantageous than other two binders. As there is no difference observed in physical properties in three ingredients, maize and rice bran are also suitable as binders. Selection of plant ingredient and suitable ratio depend on protein level and storing period of additive as required by farmer.

Keywords: Fish feed, Feed binders, Feed additives, Temperature autolysis, Shellfish waste

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Breeding performance of *Pterophyllum scalare* (Angelfish) fed with enriched *Daphnia magna*

M.R. Mohamed Rashath[1]*, A.C.W.W.M.C.L.K. Coswatte[1], P.M. Withanage[2], N.P.P. Liyanage[1]

[1]Department of Animal science, Uva Wellassa University of Sri Lanka, Badulla, Sri Lanka
[2]Ornamental Fish Breeding & Training Centre-NAQDA, Rambadagalla, Kurunegala, Sri Lanka

Ornamental fish industry is a popular and profitable trade in the world. The production cost of ornamental fish varies with the cost of fish feed. The objective of the study was to investigate the breeding performance of *Pterophyllum scalare* fed with enriched *Daphnia magna*. The live feed of *Daphnia magna* was enriched with culture media, contained 58% crude protein and artificial feed with 40% crude protein were used to feed *Pterophyllum scalare* brooders (body weight 10g – 27g) as treatment I and II respectively. Square cement tanks with a size of 0.45×0.45 m^2 were used for each treatment with 4 replicates for 80 days experimental period. Average Temperature, pH, Dissolved Oxygen, and Alkalinity in the two treatments were maintained at 28 °C, 7.4, 6.9 ppm and 560 mg l^{-1} respectively. Although the brooders spawned in both treatments, the relative fecundity was not significantly different ($P>0.05$). Other breeding performances such as fertilization rate, spawn recovery and spawning period have shown significant differences ($P<0.05$) between Treatment-l and Treatment-ll. Comparatively highest fertilization rate (93.19%) and survival rate (70.87%) were observed in the Treatment-l, whereas lowest (fertilization rate: 67.31%) (survival rate: 50.55%) in Treatment-ll. Most of the eggs in the Treatment-ll remained immature. Highest breeding performance was resulted with enriched *Daphnia magna* when compared to artificial feed in *Pterophyllum scalare*. The results revealed that the nutritional quality of the live feed considerably influenced on the breeding performance of *Pterophyllum scalare*.

Keywords: Enrichment, Brooder fish, Breeding performance, *Pterophyllum scalare, Daphnia magna*

Effect of Raw *Spirulina platensis* Supplement on the Growth Performance of Guppy Fish – Red Blonde (*Poecilia reticulata*)

M.A.D.P.I Sarathchandra*, A.S. Mahaliyana, A.C.W.W.M.C.L.K. Coswatte and S.C. Jayamanne

Department of Animal Science, Uva Wellassa University, Badulla, Sri Lanka

Aquarium fish industry in Sri Lanka has become a valuable source of foreign exchange recently. Guppy fish (*Poecilia reticulata*) ranks the highest (67%) market of ornamental, fresh water fish export sector in Sri Lanka. *Spirulina platensis* is one of the commercially important micro algae due to its overall nutritional qualities. The study was investigated the effect of dietary supplementation of different percentages of *Spirulina platensis* (5%, 10%, 15%, 20%, and 25%) on growth performance, Feed Conversion Rate and survival rate in guppy and were compared with commercial feed as the control treatment. *Spirulina platensis* were cultured using axenic batch culture method in Zarrouck's medium, under illumination with a photo period of 12 hours light and dark. Glass tanks (0.3 m × 0.15 m × 0.15 m) were used for each treatment with 3 replicates and 21 days old red blond guppy were reared with a stocking density of 10 fish/tank for 30 days. Fish were fed, twice per day at a rate of 10% of body weight for 60 days. Data were collected every 2 weeks interval and analyzed by One Way Analysis Variance (ANOVA). There were significant differences between all the diets in terms of average body weights ($p<0.05$). Average body weight was highest in treatment with 5% raw *Spiruina platensis* incorporated feed (0.45±0.09g) and lowest in control treatment (0.36±0.13g). No significant differences were observed in weight gain and Specific Growth Rate (SGR) ($p>0.05$) according to the treatments. There were significant differences of Feed Conversion Ratio (FCR) among all the diets ($p<0.05$), while it was lowest in 5% raw *Spirulina platensis* incorporated feed (1.43±0.06) and highest in the control treatment (2.05±0.09). 100% survival rate was observed in all treatments. The study revealed that 5% raw *Spirulina platensis* dietary supplementation enhances the growth rate in guppy fish.

Keywords: Dietary supplementation, Growth performance, *Poecilia reticulata*, *Spirulina platensis*

Effect of Four Formulated Diets on Colour Enhancement of Platy Fish, (*Xiphophorus maculatus*)

K. K. K. Premawansha[1], A.C.W.W.M.C.L.K. Coswatte[1], N. P. P. Liyanage[1], and M. P. K. S. K. de Silva [2*]

[1] *Department of Animal Science, Uva Wellassa University, Badulla, Sri Lanka*
[2] *Department of Zoology, University of Ruhuna, Matara, Sri Lanka*

Skin colouration is one of the most important factors which determines the commercial value of ornamental fish. Pigmentation in the skin is responsible for different colouration of fish. Pigment enriched feed is a reliable method, because hazardous effect of fish is considerably reduced. Objective of this study was to determine the colour development of platy fish subjected to four different diets. Four formulated diets were prepared using autolyzed ground shrimp head, autolyzed ground crab shell, dried & ground carrot as supplements and control diet without supplement. Twenty-five percent (25%) supplement was used for each diet preparation and other ingredients were common to all formulated diets consisted of the rest of 75% in the diet. Additional 25% of fish meal was used instead of supplement in the control diet. Experiment was conducted using five-day old platy as 30 individuals /tank and each treatment was triplicated. Laboratory conditions were maintained at 26±1 ^{0}C of temperature under natural photo periods for 75 days. Fish were fed two times per day until satiation. Photographs were captured in every 2 week interval by a same person with the same camera (Canon EOS 1300D) at a distance of 5.5 cm and 90^0 of angle at same condition for colour comparison. Pigmentations in the platy fish of each treatment were compared using a Mathematical language function which is called image analysis. Collected data were statistically analyzed using one-way ANOVA at $p<0.05$ of significant level by SPSS 24 software. According to the results, colour intensity of the platy fish fed with the feed containing autolyzed ground shrimp shell were significantly different (0.192±0.005) from the other three diets. All three experimental diets with carotenoid pigments at different levels had enhanced the colour of the fish. Present study reveals that the autolyzed shrimp head supplement is a good candidate in improving the colour of the platy fish.

Keywords: Shrimp waste, Platy fish, Autolysis, Carotenoid, Colour enhancement

Determination of Growth Performance and Meat Quality Traits of Broilers Fed Different Levels of Dietary Salt

A. Geerththana[1], H.K.T. Awanthika[1], R.M.H. Tharangani[1], Dinesh D. Jayasena[1], L. Ang[2], S. Karthika[1], W.H.D.S.P. Macelline[2]

[1]*Department of Animal Science, Uva Wellassa University, Badulla, 90000, Sri Lanka*
[2]*New Hope Lanka Ltd, Sri Lanka*

Addition of dietary salts in the feed can beneficially affect maintain the acid-base equilibrium and ionic balance of animals. The aim of this study was to investigate the growth performance and meat quality traits of broilers fed different levels of dietary salt. A total of 750 one-day-old chicks (Cobb-500) were allotted for five treatments and three replicates according to completely randomized design. Feeding program consisted of three phases (1-14, 15-28, 29-35 days of age). Controlled treatment (T1) included only basal feed while other four treatments had different concentrations of dietary salt (0.45 and 0.55%) in short term (1st day to 28th day) and long term (1st day to 35th day) basis (T2: 0.45% for long term; T3: 0.55% for long term; T4: 0.45% for short term; T5: 0.55% for short term). The initial body weight, final body weight and daily feed intake were recorded and feed conversion ratio (FCR) was calculated. Birds were slaughtered at 35th day and used to estimate dressing percentage,organ weightbody weight ratio percentage and proximate analysis, meat quality parameters and sensory evaluation of their breast meat. Data were analyzed by one way analysis of variance using General linear model procedures of Minitab 17 software. The highest body weight gain, feed intake and dressing percentages were shown by broilers fed with T3 ($P < 0.05$). The lowest FCR was shown by broilers fed with T3 ($P < 0.05$). Broilers fed with T5 and T2 had the highest water holding capacity in their breast meat ($P < 0.05$). The highest a* value (redness) in breast meat was shown by broilers fed with T1 ($P < 0.05$). However, addition of dietary salt to broiler diet had no significant effect on organ weight - body weight ratio percentage, proximate analysis and sensory evaluation of breast meat ($p > 0.05$). It can be concluded that addition of 0.55% dietary salt for long term showed significantly high growth performances in broilers.

Keywords: Broilers, Dietary salt, Growth performance, Breast meat, Feed conversion ratio

Sustainable Animal Production: Poster Presentations

Effect of *Aspergillus* Extracted Phytase Enzyme Incorporated Diets on Growth Performance, Meat Quality and Phosphorus Utilization in Broilers

S. Karthika[1], H.K.T. Awanthika[1], A.S. Kumar[1], R.M.H. Tharangani[1], Dinesh D. Jayasena[1], L. Ang[2], A. Geerththana[1], W.H.D.S.P. Macelline[2]

[1]*Department of Animal Science, Uva Wellassa University, Badulla 90000, Sri lanka*
[2]*New Hope Lanka Ltd, Sri Lanka*

Phytate is a major unavailable form of phosphorus for broilers. Addition of microbial phytase in poultry diets has increased recently to reduce the usage of Di Calcium Phosphate (DCP). A total of 810 day old (Sex ratio 1:1) Indian River chicks were used in 35 days experiment to determine the effect of *Aspergillus* extracted phytase (Natuphos ® E) enzyme on growth performance, meat quality, phosphorus utilization and investigate the phytase is a suitable replacement for DCP usage in the diets of broilers. Birds were randomly allotted for 3 groups in a complete randomized design. The control group (T1) were fed with basal feed and three levels of DCP (Booster 0.82%, Starter 0.75%, Finisher 0.80%) while other two groups were fed with basal diet with 0.01% (T2) and 0.02% (T3) phytase levels (DCP replaced by limestone). Average final body weight and feed intake were recorded and feed conversion ratio (FCR) was calculated. Feces analysis was conducted in last 3 days of metabolic trial. Blood collected and birds were slaughtered to estimate length of Shank and Tibia, meat quality traits of thigh and tibia ash analysis on the 35th day. Data were analyzed by one way ANOVA (Minitab 17). The highest feed intake, P% and Ca% of tibia bone was shown by T2 ($P < 0.05$). The highest body weight gain, shank length and crude protein% were shown by T2 and T3 ($P < 0.05$). The lowest FCR was given by T3 ($P < 0.05$). The highest tibia bone length, P availability, Ca% and P% of thigh meat were shown by T3 ($P < 0.05$). The lowest Ca% in serum analysis was given by T2 and T3 ($P < 0.05$). In sensory evaluation, T2 and T3 are most preferable in juiciness and tenderness of the leg meat ($P < 0.05$). It can be concluded that fed with *Aspergillus* extracted phytase diet enhanced the availability of phosphorus that supported the growth performance, increased P content, retention of Ca and P. These results showed that the feasible supplementation of 0.02% (T3) phytase diet can be replaced DCP usage by adding limestone.

Keywords: Broilers, Growth performance, Phosphorus utilization, *Aspergillus* extracted phytase, Tibia bon

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Effect of Diets Incorporated with Dried and Autolyzed Shrimp Waste on Growth Performance of Goldfish (*Carassius auratus*)

R.M.C.P. Rathnayake[1], N.P.P. Liyanage[1], J.A. Athula[1], K.P.G.K.P. Guruge[1], W.A.R.K. Senaarachchi[2]

[1]*Department of Animal Science, Uva Wellassa University, Badulla, Sri Lanka.*
[2]*Agri-Star compost, Peliyagoda, Sri Lanka.*

The shrimp processing industry turns out tons of head, tail and shell waste every year and this is a rich source of protein that could be used to prepare aquaculture feeds. The efficiency of different methods for extracting protein from shrimp waste were observed. This study has been designed to assess the possibility of partial replacement of fish meal with shrimp waste in diets formulated for goldfish. Known amount of shrimp waste samples were subjected to autolysis and subsequently subjected to oven drying and make fine powder. Crude protein, crude lipid, ash and moisture were estimated for both autolysed and powdered dried shrimp waste (purchased from Agri-Star Compost private limited). Two different diets were prepared by incorporating autolysed shrimp waste powder and dried shrimp waste powder as supplementary source of protein. Commercial feed that contains 42% protein was used as the control diet. Uniform sized glass tanks were stocked with twenty individuals with an initial mean weight of 0.13 ± 0.00 g per tank. Fishes were hand-fed daily three times per day for 30 days with three diets. Wet weight of the fish were measured weekly. Feed Conversion Ratio (FCR), Specific Growth Rate (SGR), Protein Efficiency Ratio (PER) and Condition Factor (K) were calculated for each diet. The highest protein level (65.55% ± 0.60) and lowest ash level was observed (11.35% ± 0.03) in autolysed shrimp waste. Significantly higher SGR, PER and survival rate (91.25% ± 3.15) were observed in individuals fed with diet incorporated with autolysed shrimp waste while significantly low FCR was observed in the same ($P<0.05$). Condition Factor was not significantly changed among the test diets ($P>0.05$). The findings of this study indicate that autolysis is the best method to extract protein form shrimp waste. During the process of autolysing meat part was detached from the shell and extracted to the aqueous medium. This process will facilitate to collect comparatively pure source of protein with compared to the dried shrimp meal. Therefore, autolyzed shrimp waste powder that contains significantly higher protein percentage can effectively enhance the growth parameters while use as protein supplement in the diet of goldfish.

Keywords: FCR, SGR, Fish feed, Fish nutrition, Ornamental fish.

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Development of Fishmeal using Knifefish *Chitala ornata*

S.P. Wanniarachchi, N.P.P. Liyanage
Faculty of Animal Science and Export Agriculture, Uva Wellassa University of Sri lanka

and

E.D.M. Epasinghe
National Aquatic Resources Research and Development Agency

Introduction

Knifefish (*Chitala ornata*) is a freshwater fish introduced to Sri Lanka as an aquarium ornamental fish in 1980's (Gunawardena, 2007). They were introduced to wild habitats by accidental release and now found in the rivers and lakes in Colombo and Kalutara districts (Sriyananda, 2004). The predatory nature of the knifefish and its ability to spread fast has posed a threat to native aquatic animals in Sri Lanka, especially to endemic species. At present, knifefish is listed as one of the invasive alien species in Sri Lanka (Gunawardena, 2007). Due to their large size and predatory nature, they have lost demand as aquarium fish and they have no demand as food fish. Hence, in order to eliminate these fish from wild habitats a new use should be introduced which would encourage the fishermen to catch them. In this research the possibility of using knifefish to produce fishmeal which could be used as a protein source in fish feed was evaluated.

Methodology

Knifefish for the experiment was collected from Kalutara area. Large bones and skin were removed and flesh was sun dried for 4-5 days. Dried flesh was ground and sieved to produce fishmeal powder. Two experimental diets were prepared as treatment 1 (containing Peliyagoda fishmeal) and treatment 2 (containing knifefish fishmeal) using the trial and error method. Other ingredients used were wheat flour, soyabean meal, rice bran and fish oil. Both diets were formulated to contain 30-35%. Proximate analysis was done for the ingredients and the two diets. Feeding trial was conducted for 20 days using guppies (2.34 ±0.24 cm), male and female separately. Three replicates were used for each treatment. Length and weight of the fish were measured weekly. At the end of the experiment Feed Conversion Ratio (FCR), Specific Growth Rate (SGR), weight gain and protein efficiency ratio (PER) were determined. Production cost of 1 Kg of each diet was calculated and compared. Statistical analysis was done using two-way ANOVA using minitab16 software.

Results and Discussion

Proximate compositions of the two diets are shown in Table 01. As shown by table 2 there was no significant difference between mean values of the two treatments with respect to FCR, SGR, weight gain or the PER. There was also no effect of the interaction between the sexes and the treatments on the above parameters ($P>0.05$) according to the results of the two-way

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ANOVA. Therefore, it is possible to use knifefish fishmeal as a substitute for Peliyagoda fishmeal in fish diets.

Table 01: Proximate composition of experimental diets

Component	Treatment 1 (%)	Treatment 2 (%)
Protein	33.30±0.34	35.29±1.74
Lipid	7.98±0.22	4.25±0.43
Moisture	2.34±0.42	2.27±0.16
Ash	22.05±0.10	15.82±0.23

Treatment 1- diet with Peliyagoda fishmeal, Treatment 2- diet with Knifefish fishmeal

Table 02: Mean values of the parameters

Treatment	Sex	FCR	SGR	WG	PER
Treatment 1	Male	3.46 ±0.40	1.82 ±0.41	0.05 ±0.01	2.3 ±0.29
Treatment 1	Female	2.00 ±1.30	1.71 ±0.52	0.05 ±0.01	1.8 ±0.11
Treatment 2	Male	2.61 ±0.33	2.28 ±0.33	0.06 ±0.01	2.2 ±0.98
Treatment 2	Female	2.00 ±1.10	1.95 ±0.06	0.05 ±0.00	2.7 ±1.14

FCR- feed conversion ratio, SGR- specific growth rate, WG- weight gain, PER- protein efficiency ratio

When the production costs of 1 Kg of each diet were compared, it was more expensive to produce the diet with knifefish fishmeal than with Peliyagoda fishmeal. This was due to the high cost incurred on the production of knifefish fishmeal. If the whole fish was used for the production of fishmeal instead of using only the flesh, cost of production could be reduced. However results of the proximate analysis showed higher ash content in Peliyagoda fishmeal (26.6±0.25) which shows that it contained higher amounts of impurities in contrast to the composition of knifefish fishmeal (7.55±0.07) which contained only the flesh of the fish.

Conclusion

Knifefish fishmeal and Peliyagoda fishmeal have similar protein efficiency ratios and similar effect on growth of guppy. Therefore it is suitable to be used as a protein source in guppy feed. Domestic production of feed using knifefish fishmeal by fishermen could be encouraged.

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Development of a suitable culture media for mass culture of *Moina macrocopa*

G. N. M. De Silva and S. C. Jayamanne
Faculty of Animal Science and Export Agriculture, Uva Wellassa University of Sri Lanka

and

W. P. R. Chandrarathna
Ornamental Fish Breeding and Training Centre, Rambadagalla, Sri Lanka

Introduction

Live food organisms contain of all the nutrients such as essential proteins, lipids, carbohydrates, vitamins, minerals, amino acids and fatty acids (Das *et al.*, 2012). Mostly, *Artenia naupli* is cultured as live feed in large amounts in Sri Lanka. However, the high cost is a problem. In Sri Lanka, brine shrimp can be replaced by *Moina macrocopa*. It is a cost effective live feed and important to find out a cost effective culture medium to get the highest production of *Moina macrocopa*. Therefore, this research was carried out to develop a suitable culture medium for mass culture of *Moina macrocopa*.

Methodology

Two experiments were conducted to develop a suitable method for culturing *Moina macrocopa* in National Aquaculture Development Authority (NAQDA) at Rambadagalla. Experiment 1 was conducted to find out possible culture media and to determine its concentration for mass culture. Experiment 2 was conducted to find out the best culture medium and its concentration for mass culture of *Moina macrocopa*. All bottles and tanks used in experiments were cleaned, drained and sun dried for two days and then filled with water, left for two days before using. *Moina macrocopa* for all experiments were taken from stock culture developed in NAQDA Centre at Rambadagalla. Pure culture of *Chlorella vulgaris* (1×10^4 cells per 1 ml) was acquired from NAQDA Centre at Rambadagalla. Filtered tap water was used in both experiments. In experiment 1, five culture media; mineralized cow dung, steamed cow dung, 15 min. boiled chicken manure, 30 min. boiled chicken manure, and 1 hr. boiled chicken manure were prepared with four different concentrations such as 5 g l^{-1}, 10 g l^{-1}, 15 g $l^{-1}$and 20 g l^{-1}. Different concentrations with various media tested with and without adding *Chlorella* into the medium. As control, a medium only with *Chlorella* and water was maintained. Three replicates from each treatment were maintained during experiment. Five individuals of *Moina macrocopa* were inoculated into each bottle. After that, top of the bottles were covered with a mosquito net to prevent entrance of undesired insects. They were allowed to stay 10 days and after that data were collected. Three samples from every tank were collected using 3 ml of fine dropping pipette. Samples were taken from the surface to bottom at three random points. Collected data (number of *Moina macrocopa*) were analyzed using Minitab 16 software with ANOVA, general linear model. According to the results of experiment 1, the positive culture media and their concentrations were used in experiment 2.

Selected treatments were prepared as same as in experiment 1. 150 individuals of *Moina macrocopa* were introduced into each tank. After ten days, 25 ml samples were taken as earlier and preserved using two drops of 1.007 g cm^{-3} **Lugol's solution. Values of all tanks were recorded. Data were** analyzed as in experiment 1.

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Results and Discussion

According to the preliminary experiment, there was a significant relationship between number of *Moina macrocopa* and culture medium ($p<0.05$). There was a significant relationship between medium and concentration to the number of *Moina macrocopa* ($p<0.05$). There were no results of *Moina macrocopa* in both 15 g l^{-1} and 20 g l^{-1} of mineralized cow dung media. There were no results of *Moina macrocopa* in 15 g l^{-1} and 20 g l^{-1} of steamed cow dung media. Those media may be not favorable for growth of *Moina*. There were no results found in 15 min. boiled chicken manure and 30 min. boiled chicken manure media. The major reason for boiling chicken manure is to prevent the *Salmonella* effect. Low time duration for boiling might be not enough for destroy the undesirable pathogens. There may be not a favorable environment for growth of *Moina macrocopa* in both of those media. Fig. 1 shows the possible culture media to be developed for experiment 2.

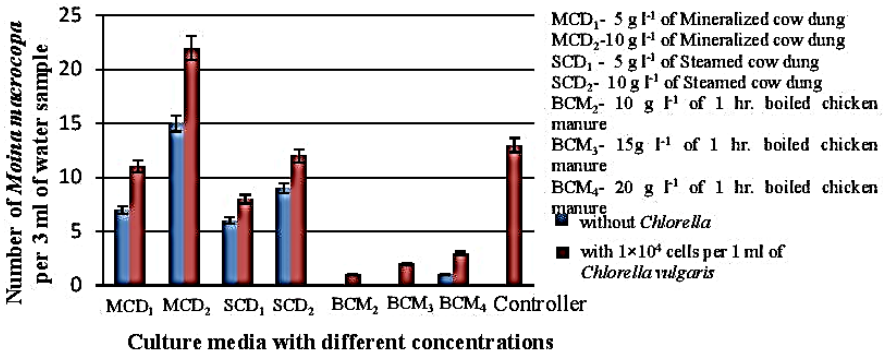

*Figure 1: **Suitable culture media and it's concentrations for culturing Moina macrocopa***

In experiment 2, according to ANOVA, general linear model, there was a significant relationship between total number of *Moina macrocopa* and medium ($p<0.05$). Table 1 shows the mineralized cow dung media and steamed cow dung media had higher results than the 1 hr. boiled chicken manure media. According to Begum *et al.*, (2013), the survival rate of individuals in cow dung is higher than chicken manure and nutritional composition of cow dung compare to the chicken manure is higher. This would be the reason for higher total number of *Moina macrocopa* in cow dung media than the chicken manure media. According to Table 1, mineralized cow dung media was better than steamed cow dung media and that results were better than the controller. Nutritional deficiency and destruction of favorable microbes which can convert complex compounds into simple absorbable minerals due to steam can be the reason for lower results in steamed cow dung. Cow dung is freely available in Sri Lanka and it is low in cost in Sri Lanka. According to the analyzed data, there was no significant relationship between total count and *Chlorella* ($p>0.05$). It means the selected culture media can be used with *Chlorella* or without *Chlorella*. But, Table 1 shows all positive resulted culture media gave higher yield with *Chlorella* than without *Chlorella*. *Chlorella* is a major food for *Moina*.. Finally, it can enhanced the available food for *Moina*.

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Table 1: Relationship of different concentrations of media and availability of *Chlorella* to the total number of *Moina macrocopa*

Medium	Concentration	Availability of 1×10^4 cells per 1 ml of *Chlorella vulgaris*	Mean ± SE Mean
Mineralized cow dung	5 g l^{-1}	With *Chlorella* Without *Chlorella*	090.00 ± 0.33 084.22 ± 0.22
	10 g l^{-1}	With *Chlorella* Without *Chlorella*	140.00 ± 0.50 129.78 ± 0.28
Steamed cow dung	5 g l^{-1}	With *Chlorella* Without *Chlorella*	065.00 ± 0.41 050.11 ± 0.35
	10 g l^{-1}	With *Chlorella* Without *Chlorella*	099.89 ± 0.35 072.00 ± 0.29
1 hr. boiled chicken manure	10 g l^{-1}	With *Chlorella*	007.89 ± 0.26
	15 g l^{-1}	With *Chlorella*	007.89 ± 0.35
	20 g l^{-1}	With *Chlorella* Without *Chlorella*	017.00 ± 0.23 007.78 ± 0.22
Controller		With *Chlorella*	100.78 ± 0.47

Conclusion

10 g l^{-1} of mineralized cow dung with *Chlorella vulgaris* can be used as a best culture medium to obtain highest total number of *Moina macrocopa* among the tested culture media.

Acknowledgement

I wish to express my gratitude to all the lecturers in Uva Wellassa University, Sri Lanka and all the members in Ornamental Fish Breeding and Training Centre, Rambadagalla, Sri Lanka.

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Comparison of Efficacy of Natural Yeast Cell Wall Polysaccharides (Actigen®) Against Commonly Used Antibiotic Growth Promoters in Broiler Diets in Sri Lanka

A.A.S.Y. Adikari
Uva Wellassa University, Badulla, Sri Lanka

S.S.P Silva, N. Priyankarage
Veteranary Research Institute, Gannuruwa, Peradeniya

and

N.M.N.N. Nambapana
Uva Wellassa University, Badulla, Sri Lanka

Introduction

Antibiotics have been widely used in animal production for decades in order to obtain high level of production and efficient feed utilization. Even though antibiotic growth promoters show positive effect on the performance of the livestock, use of antibiotics as growth promoters has caused some concerns in public health sectors. Transmission and the proliferation of resistant bacteria via the food chain and presence of harmful residues are the major concerns (Gunal *et al.*, 2006) since Scandinavia and European Union have imposed a ban (Castanon, 2007). The need for developing alternatives is realized and many research studies have been started to identify suitable alternative feed additives that would reduce bacteria penetration and colonization in poultry and perform the same characteristics as the antibiotics.

Many such as probiotics, prebiotics, exogenous enzymes and organic acids have been used with some success. Amongst many, yeast cell wall polysaccharides found to be consumer friendly alternative but the efficacy will vary with environment, management practices and feed. No comparative studies have been done in Sri Lanka.

This study was conducted to determine the efficacy of an alternative, natural yeast cell wall polysaccharides which are having high affinity binders that can bind competitively to bacteria and prevent there binding to bowel cells, to colonize and caused infection. In the study that was compared with the commonly used antibiotic growth promoters in Sri Lanka.

Methodology

The experiment was conducted at the experimental farm of the Veterinary Research Institute (VRI) Gannoruwa, Peradeniya. Three hundred and sixty day old broiler chicks (Cobbe 700) were divided into four treatments with six replicate groups of 15 chicks and were offered common basal diet supplemented either with natural yeast cell wall polysaccharide extract or commonly used antibiotic growth promoters (Bacitracin Methylene Disalicylate, Avilamycine) at recommended commercial levels and compared with negative control with no growth promoters for period of five weeks.

Four treatments were T1- Basal diet + Bacitracin Methylene Disalicylate, T2- Basal diet + Avilamycine, T3- Basal diet + Natural Yeast Cell Wall extract and T4- Basal diet only (control diet).

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Weekly average group body weight, average feed intake and daily mortality were recorded and the average group body weight gain & average feed gain ratio were calculated. Subsequently, five birds from each replicate were killed and carcass weight, liver, heart, gizzard and pancreas weights were recorded. Average dressing percentage was calculated. Data were analyzed using one way ANOVA with aid of statistical software Genstat.

Results and Discussion

Results of cumulative body weight gain, feed intake and feed conversion ratio are given in **the Table 1.**

Table 1: Cumulative body weight gain, feed intake, and FCR of broiler birds

Parameter		T1	T2	T3	T4	SED
Cumulative body weight gain (g)						
Day	0-7	134.6	132.8	136.9	136.9	2.2
	0-14	434.1	422.2	434.9	431.2	7.6
	0-21	909.2	881.5	914.4	905.5	0.3
	0-28	1417.5[a]	1351.7[b]	1411.2[a]	1341.2[b]	22.4
	0-35	2026.0	1952.0	2033.0	1983.0	60.0
Cumulative feed intake (g)						
Day	0-7	167.9	162.2	165.6	168.6	4.5
	0-14	590.1	595.2	574.5	577.2	18.9
	0-21	1257.1	1238.6	1249.3	1253.4	17.2
	0-28	2129.5	2098.1	2105.8	2062.8	26.7
	0-35	3099.0	2987.0	3032.0	3010.0	63.4
Cumulative Feed conversion ratio						
Day	0-7	1.248	1.214	1.211	1.231	0.035
	0-14	1.362	1.411	1.321	1.339	0.050
	0-21	1.385	1.409	1.366	1.385	0.037
	0-28	1.503	1.554	1.492	1.539	0.029
	0-35	1.522	1.533	1.491	1.530	0.033

As results revealed there is no significant difference between the body weights in different treatment groups (P>0.05). However, it is noted that the body weights of T4 and T2 groups were significantly lower than that of T3 & T1 groups for the first four weeks and that in almost every weighing point, body weight tended to be higher in T1 & T3 groups than that of T2 & T4. Additives are more effective when the birds are reared under poor sanitary conditions and challenged by high microbial load. However, the pen that we used for the experiment was quite new and has had no birds for last three months. This may have

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resulted in comparatively less microbial challenge for birds in the present experiment and hence the difference was only little evident. Nevertheless the trend is quite obvious that T1 & T3 diets were quite superior to T2 & T4 diets and both were equally effective as far as the growth is concerned. Had the experiment done in an actual farm situation where microbial challenge is severe, results would have been far more conclusive. In previous research natural yeast cell wall extract had been used as concentrated feed additive to improve body weight gain and feed conversion ratio, livability and performance index of animals, compared to unsupplemented diets (Ferket *et al.*, 2002) with success, our results too is supportive of their use.

According to Table 1 feed intakes and the FCR of all the treatment groups had significant difference ($p<0.05$). However, birds fed on T3 diet had relatively better FCR than any other treatments though not statistically significant. Hoog, in 2004 found that, natural yeast cell wall extract containing diet was found to produce comparable FCR with antibiotic supplemented diet in broilers. As explained earlier, quite hygienic conditions in the pens may have hindered certain effects. Also more similar to these results, research conducted by Flemming *et al.*, (2004) on the effect of inclusion of Mannan Oligo Saccharides (MOS) in the diet on the studied parameters (feed intake, daily weight gain, feed conversion ratio) were significantly higher compared to the inclusion of cell wall or to the control diet but the effect was not different as compared to the inclusion of growth promoters. However trend supports the notion that yeast cell wall extracts improves the utilization of feeds in broiler chickens. Nevertheless in the absence of statistical evidence makes it inconclusive. However, in commercial point of view little improvement of point of FCR is very valuable in profit making.

According to the results of the carcass characteristics (Table 2) there is no significant difference in the carcass weights and dressing percentages ($p<0.05$). T3 had the highest carcass weight compared to control but yet again without any statistical significance.
The organ analysis indicates that there is no significant difference in the organ weights except weights of pancreases. However, there is no apparent explanation for the difference. However carcass traits in terms of eviscerated yield of heart and gizzard were not different due to the dietary treatments confirming the earlier reports (Elangovan *et al.*, 2005).

Table 2: Effects of different dietary treatments on carcass characteristics

Parameter	T1	T2	T3	T4	SED
Average carcass Weight (g)	2195.0	2183.0	2213.0	2120.0	59.2
Dressing %	75.43	75.09	75.67	75.11	0.99
Gizzard: Carcass ratio	0.018	0.019	0.018	0.020	0.00
Heart: Carcass ratio	0.004	0.004	0.004	0.004	0.00
Liver: Carcass ratio	0.026	0.026	0.026	0.0298	0.001
Pancreas: Carcass ratio	0.0034	0.0029	0.003	0.003	0.00

Conclusion

The results of this study indicate that natural cell wall polysaccharides are equally good as best antibiotic growth promoters available in the market. In fact, it is even better in certain attributes. Therefore, they can replace antibiotics in broiler diets without any loss of performance in broilers which has a huge significance as far as the public health is concerned.

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Effect of Feeding Method and Locally Produced Blood Meal Incorporated Diet on Growth of Young Male Guppy Fish (*Poecilia reticulata*)

W. A. R. K. Senaarachchi, S.C. Jayamanne, N. P. P. Liyanage
Uva Wellassa University of Badulla, Sri Lanka

and

B.A.S.M. Bambaranda, W. P. R. Chandrarathna
Ornamental Fish Breeding and Training Centre (NAQDA), Rambadagalla

Introduction

The tropical ornamental fish production is among the most valuable industries in the world and the live bearer guppy fish (*Poecilia reticulata*) are the most popular species among hobbyists (Harpaz *et al.*, 2005). Information on dietary requirements of guppy fish has been mainly evaluated by the individual experience of the farmers and is readily available. Guppy fish is known as omnivorous and require 40-45% dietary protein level in their diet (Harpaz *et al.*, 2005). Fish feed is the single highest costly input in the ornamental fish industry and traditionally fish meal is regarded as the commonest and most popular source of protein in the commercial feed production (Otubusin *et al.*, 2009). Jonston (2005) cited in Oubusin *et al.* (2009) has reported that global supply of fish meal would not be sufficient to satisfy the demand in 2014. Hence, the present study aimed to evaluate the use of blood meal as an alternative protein source for the fish meal in the young male guppy fish diet and the form of feeding that could be administered.

Methodology

The experiment was carried out at the Ornamental fish breeding and training centre (NAQDA), Rambadagalla. Eight hundred and ten numbers of fifty-day old male guppy fish were used in the experiment. The fish were stocked in 18 glass aquarium tanks of similar size (45 L) at the stocking density of fish/liter. Two types of feed, fish meal diet (A) and blood meal incorporated diet (B) were administrated in three different forms; pulp form, flake form and powder form. Two feed types in three feeding methods were prepared as below. Blood meal powder was prepared by drying them in an oven at 60 C^0 over 24 hours and powdered meal mixed with other ingredients in diet B as an alternative feed ingredient for fish meal. The six treatments are indicated below.

Table 1. Treatments used

Feed	Form of diet		
A. Fish meal diet (control)	Pulp (T1)	Flake (T2)	Powder (T3)
B. Blood meal diet	Pulp (T4)	Flake(T5)	Powder (T6)

Proximate composition of the fish feed is given in Table 2.

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Table 2. Proximate composition of fish feed (fish meal diet & blood meal diet /100 g)

Proximate composition	(A) Fish meal diet	(B) Blood meal diet
DE(Kcal/1Kg)	304.8	305.1
Crude Protein%	45	45.74
Crude Fat%	9.84	9.1
Crude Fibre%	3.7	3.6
Ash%	10.09	12.08
Methionine%	0.84	0.9
Calcium%	2.61	2.29
Phosphorous%	1.32	1.11

Water quality in the tanks was maintained by siphoning tanks once per every two days. Lengths (mm) and weights (g) were measured using an analytical balance (AQT- 200) with a precision of 0.01 mg and a Vernier caliper (Tricle brand) with a precision of 0.02 mm respectively. 9 fish were taken randomly for the measurements from each tank. The differences in weight gain, mean weight gain, length, mean length, relative growth rate, survival rate and water quality parameters (water appearance, Ammonia, pH, Nitrate) were tested using two-way ANOVA in two factor factorial design. The experiment was carried out for 30 days and using the data collected at the period of study following rates and ratios were calculated.

$$\text{Relative growth rate (RGR \%)} = \frac{(Wf - Wi)\ g}{Wf\ g} \times 100$$

$$\text{Daily Weight Gain (DWGg/day)} = \frac{(Wf - Wi)\ (g)}{\text{Culture period (days)}}$$

Where Wf = Final average weight at end of experiment
Wi = Initial average weight at beginning of experiment

$$\text{Survival Rate (\%)} = \frac{\text{Number of fish that survived}}{\text{Number of fish stocked}} \times 100$$

Results and Discussion

The growth performance of the guppy for six treatments is shown in Table 3 and in Figure 1. As indicated, the highest growth is obtained in feeding the diet in powder form for both diet types. It would be due to free access to the feed by the fish since powder feed is distributed all over the surface of the tank and floating longer period compared to the other feeds. The lowest weight gain is shown in flake feed.

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Study on Effect of Curry Leaves Supplementation with Broiler Feed on Growth Performance, Feed Intake and Feed Conversion Ratio of Broiler chicken

W.W.H.A. Sampath, N.M.N. Nambapana
Uva Wellassa Univesity, Badulla, Sri Lanka

and

G.A.P Ganegoda
CIC Feed (Pvt)Ltd, P.O.Box 2,No.252,Kurunduwatte Road, Ekala, Sri Lanka

Introduction

The broiler industry has developed all over the world during past few decades. When considering the production of 79.9 million broiler chicks in Sri Lanka in 2007, there is an increase in 2008, 2009 and 2010 years (Department of Animal Production and Health, 2010). The production of poultry meat and other poultry products have been drastically increased in Sri Lanka within last few years. The world broiler meat production in 2010 was 73 million metric tons (USDA-FAS, 2010). China, Brazil, European Union, Mexico are the main Broiler producers in the world (USDA-FAS, 2007). Poultry meat and other poultry products such as eggs, have a higher demand in Sri Lanka. When considering the consumption pattern of the meat in Sri Lanka, chicken meat (broiler meat) has the highest demand and broiler meat has been included in the gazette as an essential food item in Sri Lanka since 2007.

The requirement of nutrients for broilers is higher than the other livestock animals. Proper nutrition and the better intensive management practices are essentials in poultry industry. Hence feed cost is major cost component in poultry industry and it is accounted up to 60%-70% of the total cost of production. The production of feed in 2009 for poultry in Sri Lanka was 454,000 Mt. However the feed price has increased after 2008 and the profit margin of the industry has gone down (Department of Animal Product and Health, 2009).

To overcome this limitation in the industry, feed supplementation is done by the farmers/producers. The supplementation is done using low cost, available feed stuffs and without affecting the performance of birds and the quality of the meat. Performance of the animal can be increased by increasing the feed conversion by improving the internal environment modification. This can be achieved by inclusion of antibiotics into feed. Antibiotics are the chemicals those which antagonistic towards or destructive of life (The penguin encyclopedia of nutrition, 1985).

Some of other feed ingredients are used to restrict or avoid the usage of antibiotic growth promoters (AGPs). Some of those are probiotics, prebiotics, synbiotics, enzymes, acidifiers, antioxidants, phytogenic additives and herbal extracts (Pauline, 2009). The usage of natural plant based materials improves the feed intake, feed digestibility, feed conversion efficiency, the quality of the meat and reduce mortality (Hathurusinghe, 2008). Natural herbal materials increase colour lipid oxidation and reduce gut microbial content (Cross *et al.*, 2007). Essential oils, organic acids and phytogenic compounds enhance production of gastric secretions, stimulate blood circulation and reduce level of pathogenic bacteria (Buchaan *et al.*, 2008)

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This study was done to investigate the effect of curry leaves incorporated broiler feed on growth performance and feed conversion ratio of broiler chicken under field condition in Sri Lanka. For the study, the dried, blended curry leaves supplementation was used. The study hypothesized that dietary supplementation of curry leaves has an ability to improve the health, performance and reduce the cost of production of broilers.

Methodology

For the experiment, 99 day old male Hubbard flex chicks were divided into three treatment groups having 33 birds per each group. There were three treatments as control group who were fed with basal diet, 1% and 2% curry leaf supplementation respectively with basal diet. Brooding was practiced in first seven days by dividing only as treatment groups. Then each treatment group was divided into three replicates randomly in day 8th to 42nd of age. Initial body weights, weekly body weight and daily feed intake were measured during the experimental period.

Birds were provided ad libitum clean drinking water throughout the study except in vaccination protocol. Multi vitamin mixture (Vita light) was given with drinking water in first five days of the study and after vaccination. The birds were vaccinated with ND vaccine on 3rd, 14th day and Gumboro (Infectious Bursal Disease –IBD) vaccine on 14th, 21st, 28th day. Mortality and reasons for deaths were recorded throughout the period of study. During the brooding period (day 1 to 7), daily group feed intakes were recorded and weekly live body weights were measured on day eight. Following replication, body weights and feed intakes were recorded on replicate basis. In each replicate, daily feed intakes were recorded and weekly body weights were recorded on 8th,15th, 22nd, 29th, 36th, and 42nd day. Average body weight gain and feed conversion ratio (FCR) were calculated using above measurements. Each variable was analyzed using Completely Randomized Design (CRD). Data were analyzed according to the General Linear Model (GLM) of ANOVA (Minitab 14). Three curry leaves samples were taken from three lots of curry leaf powder to prepare composite sample for the analysis. The curry leaves samples were subjected to sieve analysis and proximate analysis (crude protein, crude fat, crude fiber, moisture, and total ash).

Results and discussion

Proximate analysis of the curry leave supplemented diet consisted moisture 21.98%, ash 9.92%, crude protein 6.10%, crude fat 1.00% and crude fiber 3.70%.

Results of weekly body weight gain, feed intake, FCR and Results of sieve analysis are given in Table 1 and Table 2 respectively.According to the sieve analysis 08 μm and 16 μm were the dominating particle size of curry leaf used in the experiment. According to results of experiment the body weight gain of chicks fed with curry leaves supplemented diets were higher ($P<0.05$) than the basal diet.

Final body weight gain of the birds fed basal diet was lower.($P<0.05$) than that of other two supplementary groups. These findings of the study agree with the observations of Hathurusinghe (2008) that states dietary herbal compounds improve the body weight gain and final body weight of broilers

The feed intake of chicks and FCR in curry leaves supplemented diets were lower ($P<0.05$) than that of basal diet but weight gains were high in curry leaves supplemented diets. There was no significant difference ($P>0.05$) between 1% and 2% curry leaves supplemented diets for weight gain, feed intake or FCR.

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Table 1: Weekly body weight gain, feed intake, and FCR of broiler birds

Parameter	Period (days)	Basal diet-BD (Control)	BD + 1% Curry leaves	BD + 2% Curry leaves
Body Weight Gain (g)	1-7	144.87	159.61	150.58
	8-14	361.33	381.22	372.66
	15-21	769.33	788.66	772.51
	22-28	1293.80	1288.66	1292.00
	29-35	1828.68	1726.57	1788.00
	36-42	2028.71	2235.40	2247.31
Feed Intake (g)	1-7	125.26	116.72	116.88
	8-14	414.48	404.31	402.29
	15-21	955.14	927.56	921.65
	22-28	1711.11	1659.20	1644.89
	29-35	2672.38	2567.24	2558.74
	36-42	3747.32	3589.94	3583.41
FCR	1-7	0.64	0.55	0.58
	8-14	1.00	0.93	0.95
	15-21	1.16	1.10	1.12
	22-28	1.27	1.24	1.22
	29-35	1.42	1.44	1.39
	36-42	1.80	1.57	1.56

Table 2: Results of sieve analysis

Mesh Number (μm)	Curry leaves Powder (g)	Percentage
07	02	06.25
08	10	31.25
10	05	15.62
12	02	06.25
16	07	21.87
30	02	06.25
35	01	03.12
Bottom plate	03	09.37

Conclusions

Dietary supplement of curry leaves into broiler feed significantly improves the Body Weight Gain (BWG) and decreases Feed Intake (FI) and Feed Conversion Ratio (FCR) in an effective manner. The current study revealed that the curry leaves can replace dietary antibiotics and since there was no significant difference between 1% and 2%

curry leaves supplementation on the BWG, FI and FCR, 1% curry leaf supplementation is adequate to be used in broiler industry. The study showed that there is a potential to add value to nationally available curry leaf plant through the broiler feed industry.

However, further studies are needed to investigate new phytogenic feed additives with more available herbals and medicinal plants in Sri Lanka.

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Preliminary Study on Effect of Different Feed Combinations on Captive Breeding of Anemonefish *Amphiprion Clarkii*

P.R.A. Pathirana, S.C. Jayamanne, N.P.P.Liyanage
Uva Wellassa University, Badulla, Sri Lanka

and

J. P. R. P. Kumarasinghe
Ceylon Aquatics (Pvt) Ltd., Galayaya, Pannala, Sri Lanka

Introduction

The marine ornamental fish trade began in the 1930s in Sri Lanka (Buckner, 2004). Harvesting marine species for home aquaria has started in 1980s (Andrews, 1990) and the exports have continued to increase in 1990s (Vallejo, 1990). The trade has expanded to a multi-million dollar business and 45 countries supply global markets an estimated 14-30 million fish annually. The largest suppliers are Indonesia and the Philippines, followed by Brazil, Maldives, Vietnam, Sri Lanka and Hawaii. Approximately 150 species of marine fishes are exported from Sri Lanka and all these come from the wild catches. Even though Sri Lanka has a vast potential for marine ornamental fish trade, it has not developed technology on breeding marine ornamental fish in captivity. Anemone fish, *Amphiprion clarkii* is a species which has a high demand among marine aquarists due to its attractive colours and behavioural display. The fish is caught from the wild destroying the natural habitats due to improper catching methods and may decrease the population. The genus *Amphiprion* represent the most important group of captive bred marine species (Olivia *et.al*, 2006) and the present study aimed to find the possibility of stimulating breeding in *Amphiprion clarkii* in captivity using two different feeds to reduce the pressure on the natural environment.

Methodology

Four glass tanks of the size (91.5 cm X 47 cm X 38 cm) were used for the study and all the tanks were set up in a same height providing equal amount of light and temperature. The bottom of each tank was filled with same amount of cleaned coral sand and gravel just enough to cover the bottom. Two cleaned clay pots were placed in each tank providing hiding places and a substrate to deposit their eggs. Each tank was connected to a triple pass type protein skimmer (400 l per hour) and a biological filter (Figure 1). All the tanks were supplied with aeration and were numbered. Purified and disinfected sea water was transported to Pannala from Marawila area. Each tank was filled with a volume of 129 l sea water and recirculation system was in operation throughout the study. Salinity of the water was adjusted around 30 – 31 ppt. Four pairs of anemone fish (Male: around 4 cm, Female around 8 cm) paired out naturally were obtained from the coral reef environment of Tricomalee sea. One pair of fish was introduced to each tank after circulating the water system for 24 hours. Two different feeds were prepared to feed the fish as formulated feed and the mussels. Mussel feed was prepared by grinding cleaned mussels and the formulated feed was prepared by grinding the cleaned ingredients; fish (50%), seaweeds and prawns (20%), cuttlefish (15%), mussel meat (15%) with garlic.

Feed preparation was done bi-weekly. Tank number one and three were fed with a formulated frozen feed and tank number two and four were fed with mussel meat at ad

libitum for three times per day. Changing and siphoning of water was done once a week and salinity was adjusted around 30 ppt. Fish were observed three times per day for their behaviors and all the information was recorded. Tanks were specially checked for eggs in the morning and afternoon. Salinity and temperature in the tanks was checked three times a day using a digital salinity meter and a temperature meter (YSI 30) respectively. Ammonia levels were checked with an ammonia meter (HANNA: HI 96733) twice/month and the level of ammonia was maintained between 0 - 0.001 ppt. Data were collected for three months and were analyzed with two proportion z test in MINITAB 14 statistical package.

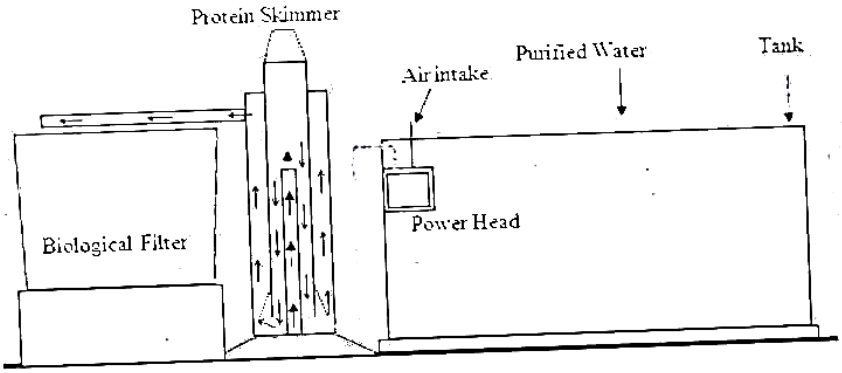

Figure 1: The water filtering and circulating system

Results

The fish that were fed with formulated feed diet started pre-spawning behavior after eight weeks after stocking while those fed with mussel did not show any spawning behavior. During the pre-spawning period fish rarely swam around the tank and at first, the female selected a specific place and stayed there and after several days same place was occupied by the male. Then, cleaning of the substratum was started by the female and later both male and female engaged in cleaning. The results indicated that formulated feed has a significant effect ($P<0.05$) on stimulating spawning behavior in *A. clarkii*. The pre spawning behavior was limited to a period of fourteen days but spawning did not materialize. The environmental factors, salinity, ammonia, nitrate and nitrite remained constant during the experimental period but the temperature has shown fluctuations. The temperature showed a significant effect on the pre-spawning behavior ($P\leq0.05$) and the pre-spawning behavior was interrupted when the temperature increased greater than 27 ^{0}C.

Discussion

The results of the study has shown that the formulated feed has a significant effect ($P<0.05$) on the breeding of *Amphiprion clarkii*. When the temperature level began to increase the pre spawning activities were stopped by the fish. According to the previous records, Dalia and Svedang (1997) has shown that water temperature has a very marked effect on the psychological and biochemical process in fish, and a raised temperature regime has a complex effect on fish reproductive, nerve and endocrine system. The

temperature presumably effect on both GtH (Growth Hormone) secretion and the responsiveness of target organ to hormonal stimulation. Increased temperature affects the fat synthesis, metabolism and endocrine system which results in the failure of the generative processes. The histological analysis revealed high frequencies of egg resorption and the gonads developed arhythmically (Dalia and Svedang, 1997) . Most of fish including *Amphiprion clarkii*, are external fertilizers. The external environment should have the ability to protect the eggs with suitable conditions. When the environmental factors are suitable, gametes are released to the environment by fish after having several behaviors (Pre spawning behaviors). These behaviors are induced by the endocrine state of the fish. According to Dalia and Svedang (1997) if the environmental temperature is raised, it is affected negatively to the endocrine system of the fish. According to Wood and McDonald (1996) there is a close association between reproductive behaviors and endocrine state, and any environmental factor (i.e. Temperature) that interferes with normal endocrine functions may also disrupt behavioral processes.

Conclusions

The formulated feed used in this study is a good source of nutrients as a brooder feed in breeding anemonefish, *Amphiprion clarkii* in captivity. The water circulating system which was used in tanks kept low levels of dissolved compounds and ammonia is efficiently removed by the system. The fish can survive without any disturbances up to 30^0C, but the spawning activities has not taken place in temperatures above 27^0C and higher temperatures affected spawning activities of *Amphiprion clarkii* negatively. The results are encouraging and need further research to succeed in breeding of *Amphiprion clarkii* in captivity.

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