Journal of Technology and Value Addition, Volume 7 (2), July 2025: (39-53)

Research Article

Development of a Nutrient-Rich Instant Beverage Powder from Vacuum-Dried *Lavulu* (*Pouteria campechiana*) and Lime (*Citrus aurantiifolia*) Fruits with Quality Parameter Evaluation

A.C.H. Sirisooriya[1,2] and D.S.W. Rajapaksha,[2,3*]

surakshir@tec.rjt.ac.lk

[1]Food Research Unit, Gannoruwa, Peradeniya, 20400, Sri Lanka
[2]Faculty of Agriculture, Aquinas College of Higher Studies, Colombo 08, Sri Lanka
[3]Department of Food Technology, Faculty of Technology, Rajarata University of Sri Lanka, Mihintale, Sri Lanka

Abstract

This research aimed to develop a beverage powder mixture derived from Canistel (Pouteria campechiana (Kunth) Baehni*), known locally as "Lavulu," an underutilized fruit crop in Sri Lanka. The primary aim of this study is to enhance the utilization of lavulu fruit among consumers as a value-added product in the form of a beverage powder. Incorporating lime fruit (Citrus aurantiifolia (*Christm.*)* Swingle*) can enrich the flavour while masking the unpleasant taste of the lavulu drink. Four distinct drink mix powders were created, combining vacuum-dehydrated lavulu powder and vacuum-dehydrated lime fruit powder in varying ratios: T1: 100% lavulu powder, T2: 75% lavulu with 25% lime fruit powder, T3: 50% lavulu with 50% lime fruit powder, and T4: 25% lavulu with 75% lime fruit powder. Among four formulations, the combination of 100% vacuum dehydrated lavulu beverage powder mixture with a °Brix value of 9.43% and a titratable acidity of 0.416%, gained the highest score in the hedonic sensory test. Proximate analysis of this 100% selected beverage powder mixture revealed 2.7 g of moisture, 94.2 g of carbohydrates, 0.8 g of protein, 0.6 g of fat, 0.2 g of crude fibre, and 1.5 g of ash content per 100 g of dried powder, providing 385 kcal of energy.*

***Keywords**: Beverage Powder, Canistel, Lime, Vacuum Dehydration*

1. Introduction

Canistel, also known as *lavulu* (*Pouteria campechiana* (Kunth) Baehni), boasts significant nutritional richness, including protein, fibre, niacin, pro-vitamin A (carotene), and a moderate amount of ascorbic acid (vitamin C). However, despite its nutritional benefits, *lavulu* often goes to waste due to its inherent challenges. The fruit's dry flesh can be uncomfortable when consumed, adhering to gums and teeth. The presence of latex in unripe fruit diminishes its palatability, and the fruit's odour reduces consumer appeal, contributing to substantial wastage. *Lavulu*'s high moisture content and vulnerability to bruising result in a short shelf life, exacerbating issues of underutilization and food wastage (Pushpakumara, 2017). Moreover, Globally, food loss and waste represent significant challenges, especially for nutrient-rich but underutilized fruits like *lavulu* (Rajapaksha, 2022). Large quantities of *lavulu* are discarded at different stages of the supply chain from harvest and handling to retail and household consumption, thus leading to the loss of valuable nutrients and economic resources.

This research aimed to reduce *lavulu* wastage by transforming it into a nutrient-rich product. To achieve this, vacuum dehydration is applied to lower moisture content and preserve *Lavulu* fruit pulp. Additionally, lime is incorporated into the study to complement *lavulu*'s nutritional profile. Limes are rich in carbohydrates, fibres, antioxidants, water, and vitamin C, presenting an opportunity to create a fusion drink powder that leverages the strengths of both fruits, providing a tantalizing flavour combination and further reducing *lavulu* wastage (Enejoh *et al.,* 2015; Abobatta, 2019).

2. Materials and Methods

2.1. Procurement of Raw Materials

Canistel (*lavulu*) fruits were collected from a specific farmer in Aranayake, Kegalle district, Sri Lanka. Lime fruits were obtained from a retail shop in Kekirawa, Anuradhapura district, Sri Lanka. Additional ingredients like powdered sugar, glucose, citric acid, salt, and carboxymethylcellulose (CMC) were sourced from a retail shop named Sun Essence Pvt Ltd. in Kandy district, Sri Lanka adhering to SLS standards.

2.2. Preparation of Fruit Powders

2.2.1. Selecting Suitable Maturity Stage of *Lavulu* Fruit

Ten *lavulu* fruits from different maturity stages were taken. Checked the colour & firmness of the fruits using fruit firmness tester (FHP-803, USA) and Royal Horticultural Society (RHS) colour chart to determine the maturity stages of the fruits and selected for sample preparation. (Mehraj *et al.,* 2015; Lozano *et al.,* 2021). Values taken from the Firmness Tester expressed as Newton (unit).

2.2.2. Preparation of *Lavulu*/Canistel Fruit Powder

Five kilograms (kg) of ripe *Lavulu* fruits were washed with running water, and the fruits were divided into two portions according to weight (2.5 kg per one portion). The skin was peeled off manually using a knife for one portion without damaging the pulp. Seeds were removed in both samples and sliced. Sliced *lavulu* were dipped in citric acid solution for preventing enzymatic browning. Then the slices were strained and steam blanched for about 1 minute. The *lavulu* sliced were kept under vacuum dry at 50 °C using microwave vacuum dryer (XL 6053, Tianshui Huayuan Pharmaceutical Equipment Technology Co., Ltd, China; maximum capacity- 40 kg; electricity consumption per one hour 12-42 kilowatt (kW); Vacuum Pressure -0.01 MPa). After completing the dehydration, dehydrated lavulu slices were packed into Poly Poplin 300 (pp300) polythene bags and grinded the slices into fine powder using micro pulverizer (28378, USA; maximum capacity -25 kg; Sieve size- 100 µm). The pulverized powder was stored in tetra laminated aluminum bags.

2.2.3. Preparation of Lime Fruit Powder

Five kilograms of lime fruits were washed with running water and sliced and removed seeds. Put it into trays and vacuum dry under 50 ^{oC} by using a microwave vacuum dryer. (XL 6053, Tianshui Huayuan Pharmaceutical Equipment Technology Co., Ltd, China; maximum capacity- 40kg; electricity consumption per one hour 12-42 Kilowatt (kW); Vacuum Pressure -0.01 MPa). After completing the dehydration, lime slices were packed into pp300 polythene bags. They were then ground into a fine powder using a micro-pulverizer (28378, USA; maximum capacity – 25 kg; sieve size – 100 µm). The dehydrated, pulverized powder was stored in tetra-laminated aluminum bags.

2.3. Determination of the Solubility of Dehydrated *Lavulu* Powders

The solubility of the dehydrated *lavulu* powders was determined based on the presence of peel and temperature of the water.

2.3.1. Determination of the Effect of the Presence of Peel on the Solubility of *Lavulu* Powder

A graduated cylinder (50 mL) was used to measure the sediments. Two grams of dehydrated powder dissolved in room temperature water. Measured the sediment over time. The sedimentation percentage was calculated according to the equation below (Equation 1).

$$\text{Sedimentation\%} = \left(\frac{Vs}{Vt}\right) \times 100$$

Equation 1: *Sedimentation Percentage*

Vs is the sedimentation volume (mL) and Vt is the total volume (mL). (Luo *et al.,* 2020; Staubmann *et al.,* 2023).

2.3.2. Determination the Effect of the Water Temperature on the Solubility of *Lavulu* Powder

A graduated cylinder (50 mL) was taken and 2 g of dehydrated lavulu powder was dissolved in 50-60 ºC hot drinking water. Measured the sediment over time. The sedimentation percentage was calculated according to Equation 1. The sediment was compared with room-temperature water.

2.4. Composition of Drink Powder Mixes

Four distinct drink mix powders were created, each with different ratios of vacuum-dehydrated *lavulu* and lime powders. These combinations included T1:100% *lavulu* powder, T2: 75% *lavulu* powder with 25% lime fruit powder, T3: 50% *lavulu* powder with 50% lime fruit powder, and T4: 25% *lavulu* powder with 75% lime fruit powder (Table 1).

Table 1: Different Formulations of *lavulu* beverage mixtures

Ingredients	T1 (100% *lavulu* mix) (g)	T2 (75% *lavulu* mix) (g)	T3 (50% *lavulu* mix) (g)	T4 (25% *lavulu* mix) (g)
Lavulu Powder	14.96	11.22	7.48	3.7
Citric Acid	2.01	-	-	-
Lime	-	3.74	7.48	11.22
Salt	1.02	1.02	1.02	1.02
CMC	0.5	0.5	0.5	0.5
Glucose	10.27	10.27	10.27	10.27
Powdered Sugar	78.91	78.91	78.91	78.91

2.5. Quality Characteristics Analysis of *Lavulu* Beverage Mixtures

Microbiological tests were carried out for the final four recipes. Aerobic Plate Count (Ref; SLS 516 Part 1: 2013) and Coliform test (Ref; SLS 516: Part 3) were determined. Beverage samples were dissolved in 50-60 ^{o}C Hot water and refrigerated before the sensory analysis. The sensory evaluations were carried out using a seven-point hedonic scale using 30 untrained panelists to check color, taste, mouth feel, appearance, aroma, and overall acceptability. pH, ^{0}Brix, Acidity% was measured in all four recipes. Moisture, protein, fat and ash content were measured for the final recipe selected from sensory analysis according to SLS 626:1983.

Untrained panelists, consisting of students and staff from Aquinas College's Faculty of Agriculture, used a ballot paper to record their sensory ratings. Samples were prepared under standardized conditions to ensure consistency in sensory perception. The feedback from these evaluations guided the selection of the final recipe, which was further assessed to verify compliance with quality standards.

2.6. Statistical Analysis

The findings of the sensorial acceptability design and other physiochemical parameters were examined statistically using the Analysis of Variance (ANOVA) and Tukey test at the 5% level of significance in SAS (version 9.4 (M7) and R (version 4.3.2) software packages to compare the means.

3. Results and Discussion

3.1 Determination of the Firmness and the Colour of *Lavulu* Fruits

According to the values, a firmness of 0 N was considered as 100% ripened, and a firmness of 192.3 N (highest) was considered as 0% ripened. Considering the range of data, the ripeness percentages of the fruits were determined (Sethuraman *et al.*, 2020; Lozano *et al.,* 2021). Typically, for *lavulu* fruits, peak organoleptic quality is achieved when they reach a yellow or orange color, signaling full maturity without a significant loss of firmness. The color plays a vital role in indicating the ripeness of these fruits before harvest (Lozano *et al.,* 2021). To calculate the percentage of ripeness for each firmness value, the formula was created considering the range of data, then the ripeness of the fruit was determined (Equation 2) (Table 2).

$$\text{Percentage of Ripeness} = \frac{(Max\ Firmness - Firmness\ Value)}{(Max\ Firmness - Min\ Firmness)} \times 100$$

Equation 2: *Percentage of ripeness*

Table 2: Determination of the firmness, ripeness% and colour of *lavulu* fruits

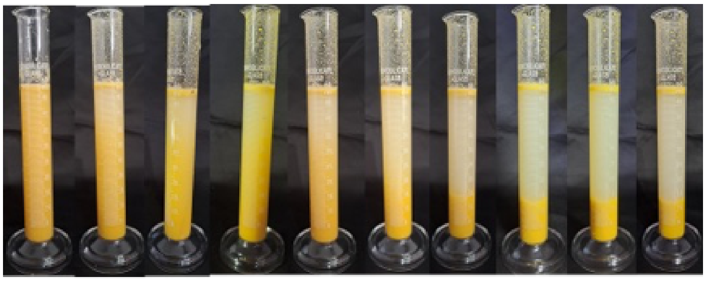
Fruit No	Firmness (N)	Ripeness%	Colour of the fruit According to RHS colour chart
1	192.26 ± 4.60^{a}	0	Yellow Green Group 151 B
2	73.93 ± 8.06^{b}	61.61	Yellow Green Group 151 C
3	$51.6 \pm 0.92^{b,c}$	73.25	Yellow Orange 16 Group B
4	$43.07 \pm 24.54^{b,c}$	77.63	Yellow Orange Group 17 C
5	$41.67 \pm 3.20^{b,c,d,e}$	78.43	Yellow Orange Group 17 B
6	$41.37 \pm 16.29^{b,c,d,e}$	78.57	Yellow Orange Group 17 A
7	$33.4 \pm 26.09^{c,d,e,f}$	82.66	Yellow Orange Group 21 B
8	$10.10 \pm 2.41^{d,e,f}$	94.75	Yellow Orange Group 21 A
9	$7.97 \pm 0.09^{e,f}$	95.88	Yellow Orange Group 23 A
10	0 ± 0^{f}	100	Yellow Orange Group 23 A

In this study, *lavulu* fruits with ripeness percentages ranging from 73.25% to 82.66% and colors ranging from Yellow Orange 16 Group B to Yellow Orange Group 21 B were chosen for analysis considering the peak organoleptic quality is achieved when they reach a yellow or orange color, signaling full maturity without a significant loss of firmness. (Lozano *et al*., 2021).

3.2 Determination of the Solubility of *Lavulu* Powder

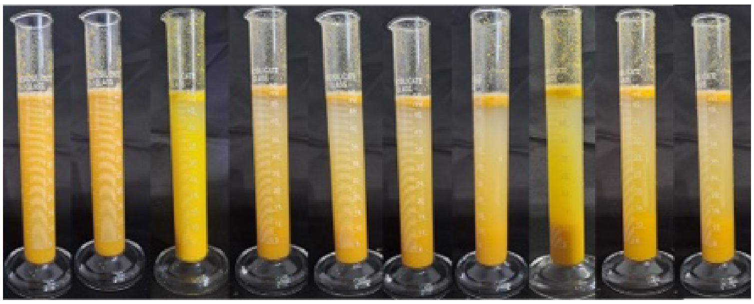
3.2.1 Sedimentation Percentage of *Lavulu* Powder with and Without Peel

Sedimentation percentage was taken by measuring the sediment volume with and without peel powder samples dissolved in room temperature water (27-30 ºC) for about 20 minutes (Figures 1 and 2). The sedimentation percentage was calculated according to Equation 1.



2 min | 4 min | 6 min | 8 min | 10 min | 12 min | 14 min | 16 min | 18 min | 20 min

Figure 1: Sediment of the powder prepared from *lavulu* fruit with the peel in a solution over time



2 min | 4 min | 6 min | 8 min | 10 min | 12 min | 14 min | 16 min | 18 min | 20 min

Figure 2: The sediment of the powder prepared from *lavulu* fruit without the peel in a solution over time.

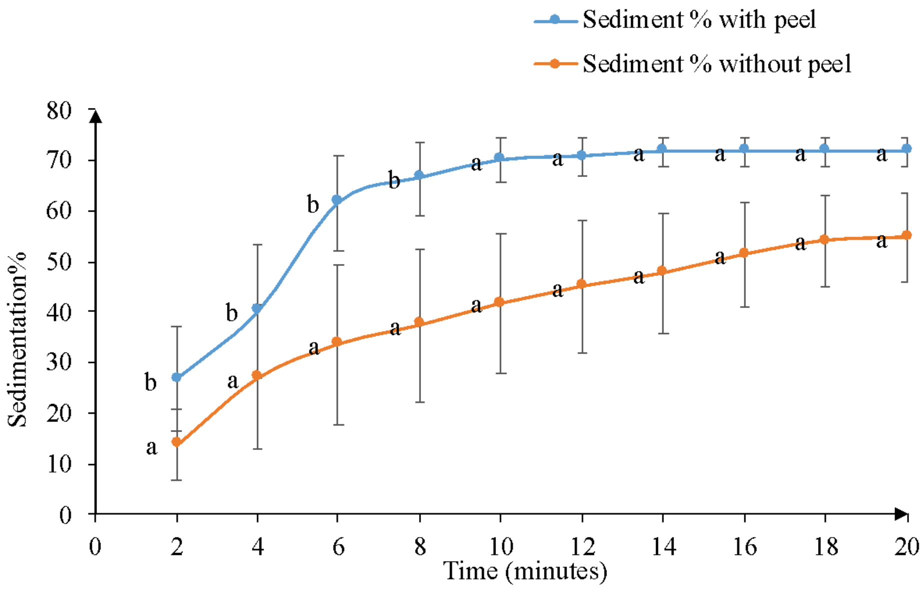


Figure 3: Sedimentation Percentage of *lavulu* powders with and without peel dissolved in room temperature water.

Values with a, b different letters indicating in the same line are significantly different (*P* < *0.05*).

When comparing the sedimentation volumes, the samples with peel powder consistently show higher values than those without peel powder across all time points (Figure 3). It is also indicated by the "a" and "b" superscript letters which indicate the statistically significant difference ($p < 0.05$) between mean values. Therefore, the data indicates that without peel *lavulu* samples have lower sedimentation volumes compared to with peel samples, and this difference is statistically significant. Hot water contains more energy, causing its molecules to move faster compared to cold water. Consequently, substances dissolve more rapidly in hot water as the increased molecular activity accelerates the breakdown process. Therefore, *lavulu* samples without the peel may be a better choice for beverage preparation.

3.2.2 Sedimentation Percentage of *lavulu* Powder Without Peel Dissolved in Room Temperature Water and Hot Water

Sedimentation percentage was taken from measuring the sediment volume without peel powder samples dissolved in room temperature water (27-30 °C) and hot water

(50-60 °C) about 20 minutes of time (Figures 4 and 5). The sedimentation percentage was calculated according to Equation 1.

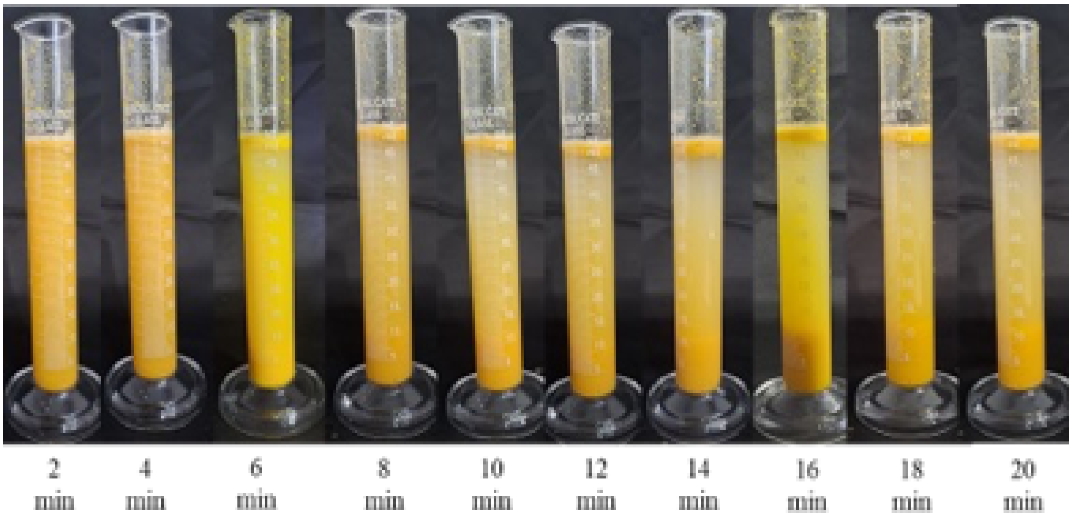


Figure 4: Sediment measured for lavulu fruit powder samples dissolved in room temperature water (27-30 °C)

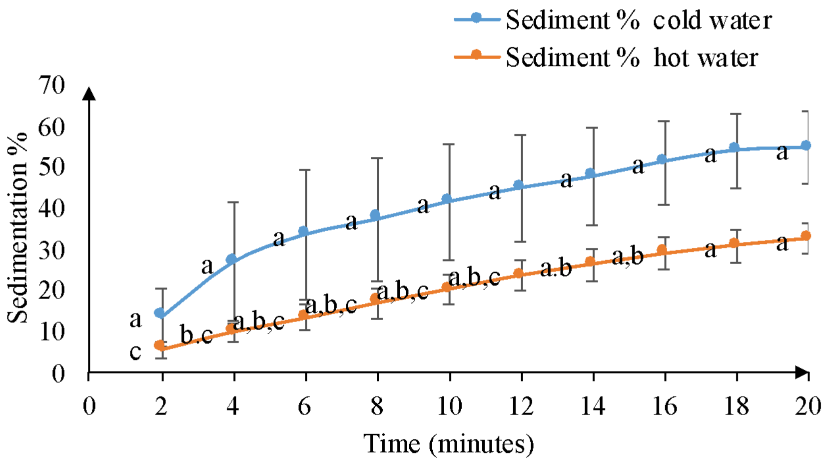


Figure 5: Sediment measured for lavulu fruit powder samples dissolved in hot water (50-60 °C)

Values with a,b,c different letters indicating in the same line are significantly different (*P* < *0.05*).

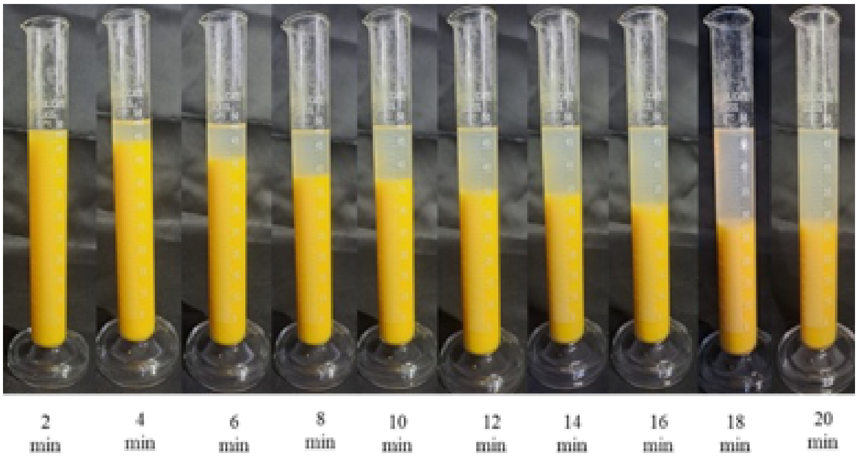


Figure 6: Sedimentation percentage of *lavulu* powder without peel dissolved in room temperature water and hot water

It clearly represents the comparison between sedimentation volumes without peel powder dissolved in room temperature water that are consistently higher than those without peel powder dissolved in hot water samples for all time points (Figure 6). The data indicates that without peel *lavulu* powder dissolved in hot water samples have lower sedimentation volumes compared to without peel powder dissolved in room temperature water samples, and this difference is statistically significant. This might be due to higher insoluble matters such as cellulose and hemicellulose in the peel. Therefore, utilizing hot water is a preferable choice for beverage preparation.

3.3 Physicochemical Properties of Beverage Powder Recipe Mixes

The physio-chemical parameters of the sample changed based on the composition, as illustrated in Table 3.

The Sri Lanka standards SLS 668:2022 and SLS 1328:2008 provide guidelines for flavoured drink powder mixes and fruit juices/nectars, respectively. The pH values observed in Table 3 range from 2.55 to 3.02, which are on the acidic side. The differences in pH among the samples (T1-T4) are statistically significant ($p < 0.05$), as indicated by different superscript letters. These variations could be due to differences in the type and amount of acidulants used in each recipe formulation. Mainly, citric acid acts as the prominent acidulant of the recipes. The °Brix values of 9.43- 10.63, reflect soluble solids, attributable to sweetener variations. While acidity (0.19-0.45%) complied with SLS 668's 3.5% maximum limit. The variations observed in pH, °Brix, and acidity among the four beverage powder recipe mixes (T1-T4) are likely due to differences in their compositions, particularly the type and amount of acidulants and sweetening ingredients used.

Table 3: Physicochemical properties of four beverage powder recipe mixes

Recipe	pH	^{0}Brix%	Acidity%
T–100% *lavulu* mix	2.63 ± 0.18^{b}	9.43 ± 0.06^{c}	0.42 ± 0.14^{ab}
T2–75% *lavulu* mix	3.02 ± 0.05^{ab}	10.63 ± 0.23^{a}	0.19 ± 0.09^{b}
T3–50% *lavulu* mix	2.66 ± 0.03^{b}	10.50 ± 0.10^{a}	0.29 ± 0.05^{ab}
T4–25% *lavulu* mix	2.55 ± 0.06^{b}	10.07 ± 0.06^{b}	0.45 ± 0.00^{ab}

The values represent the mean ± standard error of the replicates, with a-b different superscript letters indicating variations between samples. ($p < 0.05$).

The Sri Lanka standards SLS 668:2022 and SLS 1328:2008 provide guidelines for flavoured drink powder mixes and fruit juices/nectars, respectively. The pH values observed in Table 3 range from 2.55 to 3.02, which are on the acidic side. The differences in pH among the samples (T1-T4) are statistically significant ($p < 0.05$), as indicated by different superscript letters. These variations could be due to differences in the type and amount of acidulants used in each recipe formulation. Mainly, citric acid acts as the prominent acidulant of the recipes. The °Brix values of 9.43- 10.63, reflect soluble solids, attributable to sweetener variations. While acidity (0.19-0.45%) complied with SLS 668's 3.5% maximum limit. The variations observed in pH, °Brix, and acidity among the four beverage powder recipe mixes (T1-T4) are likely due to differences in their compositions, particularly the type and amount of acidulants and sweetening ingredients used.

3.4 Sensory Evaluation

The median data from consumer panel evaluations is presented, and Figure 7 visualizes the results of the sensory study. In general, significant differences between the groups for all the sensory characteristics were observed ($p < 0.05$). Recipe T1 (100% *lavulu* drink) was selected from sensory evaluation by 30 untrained panelists. The proximate analysis was carried out for the final beverage recipe mixture T1.

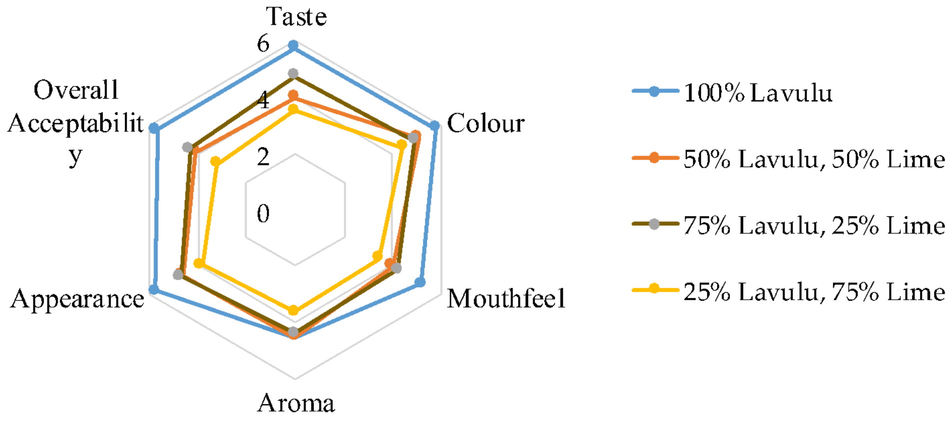


Figure 7: Radar Diagrammatic presentation of sensory evaluated attributes.

3.5 Proximate Analysis

The proximate analysis was carried out for the final beverage recipe mixture T1 which was 100% *lavulu* incorporated beverage powder mixture. Tests were carried out according to SLS 626:1983 and with reference to CODEX guidelines on Nutritional Labeling. In Recipe T1 (100% *lavulu* beverage powder), the proximate composition shown in Table 4.

Table 4: The proximate composition of Recipe T1

Test Parameter	Results
Moisture Content (g/100 g)	2.7
Ash Content (g/100 g)	1.5
Crude Protein Content (g/100 g)	0.8
Crude fibre (g/100 g)	0.2
Crude Fat Content (g/100 g)	0.6
Carbohydrate Content (g/100 g)	94.2
Energy (kcal/ 100 g)	385.4

The proximate analysis data for the developed *Lavulu* and Lime beverage powder mixture, in comparison to the standards outlined in SLS 668:2022, offers important insights into the product's compliance with industry guidelines. This analysis is vital for assessing the product's quality, safety, and potential shelf life. Moisture Content: According to SLS, the maximum allowable moisture content is 1.0% by mass. The product's moisture content is measured at 2.7 g/100 g, which exceeds the stipulated maximum limit. This variation is expected due to the inherent moisture content in Lavulu fruit. However, it's important to note that the product is made to dissolve easily in hot water. The maximum allowable ash content as per SLS is 2.0% by mass. The product registers an ash content of 1.5 g/100 g, which falls below this threshold, indicating adherence to ash content guidelines.

While SLS 668:2022 does not provide a specific standard for acid insoluble ash, the product's minimal acid insoluble ash content of 0.2 g/100 g is well within the acceptable limits, showcasing the quality of the mixture. SLS sets a maximum limit of 3.5% for acidity as anhydrous citric acid. The product registers a titratable acidity of 0.416%, indicating that it falls significantly below the specified maximum acidity level, ensuring safety and palatability.

The product contains protein, fat, crude fibre, and carbohydrates, with an energy content of 385.4 kcal/100g. These values demonstrate the nutritional composition of the beverage powder, contributing to its overall appeal as a potential value-added product. In summary, the developed *lavulu* and lime beverage powder mixture aligns with most of the standards presented in SLS 668:2022. This analysis underscores the product's potential to serve as a value-added offering derived from *lavulu* fruit through vacuum dehydration.

4. Conclusion

Among the tested formulations, Recipe T1 (100% *lavulu* powder mix) was found to be the most acceptable, offering a well-balanced sensory experience. This beverage mix provides valuable nutritional content and offers a novel value-added product for consumers. With its low moisture, high carbohydrates, and an energy content of 385 kcal per 100 g, Recipe T1, when prepared with hot water at 50-60 °C, stands out as the recommended choice. This innovative product not only reduces food wastage but also contributes to improved economic viability for *lavulu* fruit.

These findings underscore the potential of underutilized fruits like *lavulu* in reducing food waste and expanding food options. To further enhance the product’s marketability and nutritional profile, future research should examine its shelf life and beta carotene content, supporting its role in sustainable food innovation.

5. Acknowledgements

The authors wish to acknowledge the support and resources provided by the Food Research Unit, Gannoruwa, Peradeniya, Sri Lanka.

6. References

Abobatta, W.F. (2019). Nutritional Benefits of Citrus Fruits. American Journal of Biomedical Sciences and Research, 3(4), 303–306.

CODEX. (2005). General Standard for Fruit Juices And Nectars (CODEX STAN 247-2005).

Enejoh, O.S., Ogunyemi, I.O., Bala, M.S., Oruene, I.S., Suleiman, M.M., & Ambali, S.F. (2015). Ethnomedical importance of *Citrus aurantifolia* (Christm) Swingle. The Pharma Innovation, 4(8, Part A), 1.

Evangelista-Lozano, S., Robles-Jímarez, H.R., Pérez-Barcena, J.F., Agama-Acevedo, E., Briones-Martínez, R., & Cruz-Castillo, J.G. (2021). Fruit characterization of *Pouteria campechiana* ([Kunth] Baehni) in three different stages of maturity. Fruits, 76(3), 116-122.

Luo, D., Mu, T.H., Sun, H., & Chen, J. (2020). Optimization of the formula and processing of a sweet potato leaf powder‐based beverage. Food Science & Nutrition, 8(6), 2680-2691.

Mehraj, H., Sikder, R.K., Mayda, U., Taufique, T., & Uddin, J. (2015). Plant physiology and fruit secondary metabolites of canistel (*Pouteria campechiana*). World Applied Sciences Journal, 33(12), 1908-1914.

Navaratne, S. B., & Sandaruwani, C. (2014). Preservation of lime fruits under modified atmospheric conditions created in a sand bed.

Pushpakumara, D. K. N. G. (2017). *Pouteria campechiana* (Kunth) Baehni. Retrieved from http://plants.usda.gov/.

Rajapaksha, D. S. W. (2022). Integrated approach for valorisation of polyphenols in spent black tea: extraction, microencapsulation, and development of functional packaging film (Doctoral dissertation, 北海道大学).

Sethuraman, G., Nizar, N.M., Muhamad, F.N., Suhairi, T.A.S.M., Jahanshiri, E., Gregory, P.J., & Azam-Ali, S. (2020). Nutritional composition of canistel (*Pouteria Campechiana* (Kunth) Baehni). International Journal of Food Science and Nutrition, 5(6), 53-57.

Sri Lanka Standards Institution. (2022). Specification For Flavoured Drink Powder Mixes (First Revision) (SLS 668:2022).

Staubmann, L., Mistlberger-Reiner, A., Raoui, E.M., Brunner, G., Sinawehl, L., Winter, M., Liska, R., & Pignitter, M. (2023). Combinations of hydrocolloids show enhanced stabilizing effects on cloudy orange juice ready-to-drink beverages. Food Hydrocolloids, 138, 108436.