Review Article

Importance of Compositional Analysis of Traditional Agro-biodiverse Pulse Species Grown in Sri Lanka

[1*] W.M.A.A. Kulasinghe

**anupamakulasinghe@gmail.com*

[1] University Business Linkage Cell, Uva Wellassa University of Sri Lanka, Passara Road, Badulla, 90000, Sri Lanka

Abstract

Pulses play a vital role in the Sri Lankan diet as a protein source. Nutritional and health benefits of pulses are remarkable. Therefore, they have gained attention as a good source of nutrients to defeat the malnutrition in developing countries. Carbohydrates, protein, minerals, vitamins, fiber and other bioactive compound of pulses vary among different species and varieties. Sri Lanka is a valuable repository for agro-biodiversity and it is rich in genetic diversity as well. Pulses grown in Sri Lanka reflect this value and there are nearly 100 species and varieties of pulses available in this country. Most common examples are cowpea, green gram, horse gram, black gram, lentils, common beans and winged beans. There are inter-species and intra-species variations found in the nutritional values, health benefits and therapeutic effects found in these varieties. Further, they can tolerate adverse environmental conditions than genetically improved pulse varieties. Therefore, it is vital to identify pulses with higher nutritional value and high tolerance for adverse environmental conditions, pests and diseases. It will be very beneficial to get the maximum use of lands with poor environmental quality. Compositional data on Sri Lankan traditional pulses will be also useful for nutrition research, product developments, estimating/comparing the nutrient content of foods, identifying sources of particular nutrients, analyzing individuals' diets, devising special diets for patients, analyzing dietary survey data, assessing how dietary intake affects health and disease outcomes, devising special diets for epidemiological research, monitoring food and nutrient availability, development of dietary guidelines, consumer information and education, food labeling and nutrient claims and marketing etc.

Keywords: *Agro-biodiversity, Compositional analysis, Nutrition, Pulses, Sri Lanka, Traditional*

1. Introduction

Increasing population pressure, fast depletion of natural resources, poverty and low agricultural production are some of the problems associated with developing countries. It is well predictable that the developing countries do not produce plenty of food with right nutritional quality to meet the daily nutritional requirements of the total community. The dominance of hunger and malnutrition in the tropical and subtropical areas of the world is well documented (FAO, 2013). Food scarcity is emerging as a huge problem. The developing nations have to depend mostly on cereals, grains, starchy roots, and tubers for energy and pulses for protein needs. In view of prevalent food insecurity, attention is currently being focused on the exploitation of lesser-known and non- traditional plant resources (Kala and Mohan, 2010).

Sri Lanka is well known as a valuable repository of crop germplasm and agro-biodiversity. It possesses a rich treasure of legume genes with nearly 100 varieties and cultivars. These varieties show great adaptability to a wide range of climatic and soil conditions and pests and diseases. They also show differences in grain size and quality and some possess therapeutic properties and fragrance while some others are used for cultural and ritual purposes (Helvetas Sri Lanka, 2001).

Sri Lanka possesses a rich germplasm of legumes, together with cowpea, soy bean, winged bean, ground nut, pigeon pea, lentils, black grams, green gram, horse gram, common beans; cereals, including millets, sorghum and maize; fruits such as banana, citrus, mango, avocado, jack fruit, root and tuber crops (Helvetas Sri Lanka, 2001). Furthermore, Helvetas (2001) explains that landraces and local varieties explicit to sites are potential sources of valuable and rare genes. Resources of poor farmers in Sri Lanka uphold a variety of valuable indigenous germplasm. Landraces and traditional varieties are morphologically distinguishable and have different names according to their characteristics. Farmers tend to cultivate traditional varieties in small amounts, regularly in the backyards of their homes. Under adverse climatic conditions, landraces can still yield than new cultivars. However, this tradition of famer preservation and maintenance is under continuous risk because of replacement of traditional varieties with new improved uniform crop cultivars, variations of agricultural land use and destruction of habitats and ecosystems. Urgent action is required if such treasured genetic resources are to be saved or utilized.

Currently, less than 30 plant species meet nearly 90% of the world food requirement (Mai, 1994). Wheat, rice, maize, barely, sorghum, millet, potato, sweet potato, yams, sugar cane and soybean provide three quarters of the plant kingdom's involvement on the way to fulfill human dietary and energy necessities. The wealth of crop varieties built over thousands of years has gone missing at an alarming rate. Scientists all over the world now extensively agree that there is a vital need to implement corrective actions to slow down the extrication of biological diversity, predominantly diversity of food plants (Rajapaksha, 1998). Aiming on this, number of countries around the world have started assessment and preservation of traditional food plants existing in their countries (Modi, 2009; Jain and Tiwari, 2012; Ndango, 2013; Phillips *et al.*, 2014; El-amier and Abdullah, 2015; Misra and Misra, 2016).

Food consumption pattern of Sri Lankans has mainly been based on cereals, pulses and yams since ancient times. Many studies on archeology, ancient agriculture delivers enough evidences to prove this concept. Nutrient composition varies among different varieties/ cultivars/ breeds of the same species. Therefore, analyzing food composition of each variety/ cultivar/ breed is important for identify the nutrition of biodiversity species.

In the past, common food composition data were considered adequate for most purposes. Today, there is an improved consciousness focused towards the need for carrying out food composition studies that consider biodiversity, however, compositional data at the variety/cultivar/breed level are not yet generated or disseminated widely. Farmers and consumers, for example, are often unaware of the nutritional values of certain plant cultivars in comparison to the others and do not take an interest to grow or consume them (FAO, 2010). In addition to variety/cultivar/breed, physicochemical properties of agricultural outputs can vary with the environmental conditions and other agricultural inputs. This review article discusses the importance of compositional analysis of traditional agro-biodiverse pulse species grown in Sri Lanka.

2. Traditional Agriculture in Sri Lanka

Sri Lanka inherits 2500 years of history which was originated with agriculture based culture and agrarian society (Helvetas Sri Lanka, 2001). Plant based food, known as traditional, are accepted by the rural communities through their experiences, customs and habits. Everyone in the community knew cultivation, preparation and consumption patterns of those traditional varieties of food from ancient civilizations. Their taste is the base of their preparation methods and people have opinions about their nutritive and therapeutic values as well. Further, these traditional food species are grown in a specific ecosystem representing localities, which are sometimes categorized as wild, or semi wild species and varieties. Different foods and farming systems used by a particular community reflects their wealth of traditional food plant availability in their system (Rajapaksha, 1998).

Plant diversity of a particular area is highly dependent on the geographical location and its proximity to the original source. Therefore, the traditional species known by different communities vary with the geographical location as well. Sri Lanka is rich in plant diversity and it contains number of different geographical ecosystems. Nearly 3368 plant species belonging to 1294 genera and 132 families have been identified in Sri Lanka. About 800 of these are endemic to Sri Lanka, while the rest have been introduced to Sri Lanka from various regions of the world at different times (Rajapaksha, 1998).

Sri Lanka has wide variations in temperature, rainfall, topography and soil conditions. Therefore, very high degree of biodiversity is there ensuring a rich diversity in eco-systems and plant species. Sri Lankan farmers protected this over thousands of years. There is a significant diversity remaining among the major crops cultivated in Sri Lanka. In the case of rice, there are around 4,000 accessions including wild relatives, Land races and old cultivars. The other crops in the local agricultural sector and the plantation sector also have a large number of accessions, and most of these have been characterized (Muthukuda Arachchi and Wijerathne, 2007).

Sri Lankan food crop diversity has also been improved by introduction of several crops of economic significance since antiquity. The introduced types, depending on the time and the area also show secondary genetic variations. A number of crop species, viz., cereals, legumes, root and tuber crops, fruits and vegetables are of considerable value in maintaining food security of the country. In addition, some crops (e.g. Tea, rubber, coconut and spice crops) are cultivated for exportations (Muthukuda Arachchi and Wijerathne, 2007)**.**

The second farming system was shifting cultivation or slash and burn cultivation, more generally denoted as "chena cultivation". In the chenas, coarse grains and vegetables were raised under rain fed conditions. Among the coarse grains were finger millet, which was considered as the second staple, *Meneri* (millet), *Thanahal* (foxtail millet), *Amu* (Kodo millet), mustard, gingelly (sesame), green gram and black gram (Siriweera, 1993).

3. Traditional Pulses Grown in Sri Lanka and their Nutritional Values

The family Fabaceae is the second leading family after family *Poaceae* (*Gramineae*). Family *Fabaceae*, which was previously known as *Leguminosae*, is included more than 600 genera and nearly 18,000 species of cultivated plants. Food legumes are used directly or indirectly as unripe pods, green grains and dry seeds. Edible seeds of *Fabaceae* plants are also denoted as pulses (FAO, 2013).

Pulses play an important role in Sri Lankan diets, mainly as one of the protein sources. Among these, legumes are cowpea (*Vigna unguiculata*) and yard long bean green gram (*Vigna radiate*), black gram (*Vigna mungo*), horse gram (*Macrotyloma uniflorum*), soya bean (*Glycine max*), beans (*Phaseolus vulgaris*) and winged bean (*Psopocarpus tetragonolobus*). Considerable genetic diversity exists in these species. However, further investigation and characterization is required because only about 30% are so far characterized (Muthukuda Arachchi and Wijerathne, 2007). The total production of major pulses grown within the country is given in the Table 1.

Table 1: Annual production of major pulses in Sri Lanka (MT)

Year	**Green Gram**	**Cowpea**	**Dhal**	**Ground Nuts**	**Soybeans**
2005	9000	11180	1	9040	4990
2006	7980	10120	10	9820	5177
2007	8520	10850	10	9840	4799
2008	8880	11950	-	10250	3032
2009	9260	13480	-	13070	3788
2010	11700	11610	-	14350	7521
2011	10838	10453	-	16903	3847
2012	11956	14812	-	21953	1671
2013	14252	14185	-	27486	13316
2014	14350	15120	-	25430	-

Source: Department of Census and Statistics, Sri Lanka (2016)

Number of different pulses and their varieties were traditionally cultivated by farmers in Sri Lanka (Helvetas, 2001). Commonly grown traditional pulses are listed in Table 2 (Helvetas, 2001).

Table 2: Varieties and Cultivars of Traditional Pulses Grown in Sri Lanka

Variety	Cultivar
Beans (*Phaseolus vulgaricus*)	
Black grams (*Vigna mungo*)	
Cowpea (*Vigna unguiculata*)	*Rathu, Kalu, Kabara, Sudu*
Green gram (*Vigna radiata*)	*Gajamun, Heenmun, Kahamun, Kolmun, Kattamun, Lokumun, Pinnamun, Telmun, Wedamun*
Horse gram or *kollu* (*Macrotyloma uniforum*)	*Ala, Kalu, Rathu, Weda, Sudu*
Chick pea (*Cicer arietinum*)	
Mae (*Vigna spp*)	*Awara, Bin, Bu, Gasme, Hawari, Heen, Heenmae, Kolamae, Katumae, Leenamae, Mahalee, Murunga, Nil, Pathuru, Patta, Polon, Rathu, Rathupatta, Sudu, Sudukonda, Wanduru*
Pigeon pea (Cajanus cajan)	
Soya bean (*Glycine max*)	
Winged bean (*Psophocarpus teragonolobus*)	*Awara, Beti, Nil, Bonchi, Daluk, Dara, Kola, Halmessan, Heen, Iththe, Komaranga, Kiri, Koladiga, Kota, maha, Pathok, Pothu, Rathu, Wanduru*

Source: Helvetas (2001)

The pulses, also known as legumes, have been grown and used for food for eras all over the world. They are next important to cereals as sources of human food and comprise more protein than any other vegetable products. Carbohydrates and fats are also present in pulses.

Pulses are a source of supplementary protein to daily diets based on cereals and starchy food mainly for vegetarian population and for those who cannot purchase expensive animal protein. Pulses are often regarded as poor man’s meat, which provide energy, essential minerals, vitamins and several compounds considered beneficial for good health. Grain legumes in the daily intake are of nutritional value, as significant sources of human health food. Humans in different regions of the world consume legume seeds comprehensively. Legumes are important sources of macronutrients and micronutrients and in addition to flavonoids, carotenoids, and other phenolics are considered to be brilliant sources of ingredients for functional foods and other applications (Heimler, *et al.*, 2005; Madhujith, *et al.*, 2004). Figure 1 shows the structure of a gram seed.

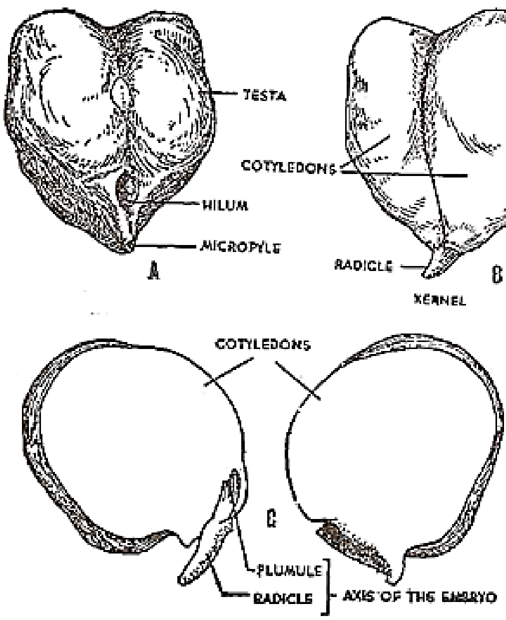

Figure 1: Typical structure of a gram seed

Source: Gupta (2016)

Food legumes establish an essential part of diet of a superior section of population in the developing world, as a good source of protein, carbohydrates, minerals and vitamins. Being rich in protein, carbohydrate, calorific value, fibre, and vitamins, legumes constitute staple food in numerous countries (Kala and Mohan, 2010). Even though pulses are rich in nutrients, their consumption is limited due to low amount of sulfur-containing amino acids, low protein digestibility and the occurrence of several anti-nutritional constituents which addressed can be avoided by different processing methods and traditional treatments such as soaking, cooking and fermentation ((Mubarak, 2005; Trugo *et al.*, 1993). Pulses comprise a similar quantity of proteins to animal-based food sources, though their nutritional quality is lower than proteins from animal sources due to their low availability of all essential amino acids. The proteins from pulses are lacking in methionine and cysteine (sulfur containing amino acids) while rich in lysine. The protein quality of vegetarian diets and plant-based diets is extremely improved when pulses are eaten together with cereals as cereals lack in lysine in the mean while high amount of methionine and cysteine are available (Ofuya and Akhidue, 2005).

The complex carbohydrates in pulses can be classified into storage polysaccharides such as starch, which is the main source of energy in a germinating seed; gums made up of galactomannans and glucomannans; and structural polysaccharides such as cellulose and hemicelluloses that compromise structural integrity to the plant. Starch content is 22–45% of the pulse grain weight depending on the source. Starch of pulses is comprised of amylase and amylopectin (Hoover *et al*., 2010). Grain, Legume and Oil Crops Research & Development Center located in Angunakolapelessa, Sri Lanka has investigated proximate composition of several local varieties of green gram, cowpea and horse gram as shown in Table 3.

Table 3: Proximate composition of selected local varieties of pulses on percent dry basis

Legume	**Variety**	**Ash**	**Protein**	**Fat**	**Crude Fiber**	**Carbohydrate**
Green bean	MI 5	3.96^{c}	25.99^{b}	1.54^{c}	5.55^{b}	62.97^{d}
	MI 6	3.95^{c}	26.56^{a}	1.25^{c}	5.01^{c}	63.23^{d}
Cowpea	ANKCP01	4.10^{b}	24.90^{c}	2.03^{a}	5.75^{b}	63.22^{d}
	MICP01	4.30^{a}	25.22^{c}	1.86^{ab}	3.04^{e}	65.58^{b}
	Bombay	3.43^{f}	24.98^{c}	1.81^{ab}	4.36^{d}	65.42^{b}
	Waruni	3.78^{d}	25.03^{c}	1.51^{bc}	6.84^{a}	62.84^{d}
	Dhawala	3.62^{e}	22.84^{e}	1.72^{ab}	5.06^{c}	66.76^{a}
Horse gram	ANK Black	3.57^{e}	21.96^{f}	0.85^{d}	6.87^{a}	66.75^{a}
	ANK brown	3.56^{e}	24.19^{d}	0.78^{d}	6.7^{a}	64.77^{c}

*Values with different letters are significantly different.
Source: Grain, Legume and Oil Crops Research & Development Center in Angunakolapelessa in Sri Lanka (2016)

Pulses consist of essential micronutrients, such as iron, potassium, magnesium, zinc and B vitamins including folate, thiamin and niacin (Global pulse confederation, 2016). They are rich in vitamins B, E, A and C. Austrailian Grains Research & Development Corporation (2008) has mentioned that pulses contain thiamin, riboflavin, niacin, vitamin B_6 (pyridoxamine, pyridoxal and pyridoxine) and pantothenic acid and also more folate than grains (Campos-vega *et al*., 2010). Pulses contain more potassium than sodium. In addition to iron, zinc, magnesium and phosphorus, pulses contain more calcium than that of cereal grains. Certain amount of manganese and copper are also found in pulses (Australian Grains Research & Development Corporation, 2008).

The content of iron and other minerals is generally high in legumes with beans having the highest mineral content, while mineral contents of legumes indicate that beans and lentils have the highest iron content (Campos-vega *et al*., 2010). Table 4 shows the availability of different minerals in several varieties of green gram, cowpea and horse gram on dry basis.

Table 4: Major minerals available in several local varieties of green gram, cowpea and horse gram on dry basis

Legume	**Variety**	**Fe (mg/Kg)**	**Ca (mg/Kg)**	**Zn (mg/Kg)**	**P (mg/Kg)**	**K (%)**
Cowpea	Waruni	38.9c	336.1c	29.6a	477b	1.35ab
	MICP	24.6e	315.5e	22c	473b	1.07bc
	Bombay	39.8c	312.5ef	31.7a	405d	1.46a
	Dhawala	26.4e	257.5g	24.3b	411d	1.22abc
	ANKCP 1	31.8d	168.5h	25.8b	445c	1.35ab
Green gram	MI05	30.6d	329.5d	19d	448c	1.14bc
	MI06	32d	309.5f	19.3d	495a	1.34c
Horse gram	ANK balck	104.2b	1286.8b	30.6a	361f	1.02c
	ANK brown	114.5a	1571.6a	30.6a	369e	1.02

*Values with different letters are significantly different.
Source: Grain, Legume and Oil Crops Research & Development Center in Angunakolapelessa, Sri Lanka (2016)

Pulses contain a number of bioactive substances that cannot be identified as nutrients, but they exhibit metabolic effects on the humans or animals that consume these food forms. These effects, which are commonly observed when pulses are consumed on a regular basis, may be regarded as positive, negative or both (Champ, 2016). As an example, beans, especially those with colored coats, have strong antioxidant activity. The tannins and other phenolic compounds, once categorized as antinutritive factors, contributed to the antioxidant capacity of beans. Besides providing major nutrients, beans serve as a rich source of bioactives in the daily diet, which might help controlling disease conditions (Madhujith *et al*., 2004).

Most bioactive substances have been classified as 'antinutritional factors' and are denoted by many different terms in the literature as toxic constituents, toxins or food toxicants, antinutrients or antinutritional compounds, bioactive substances, nutritive factors, associated substances, micronutrients and phytochemicals. Enzyme inhibitors, lectins or phytohaemagglutinins, alkaloids, phenolic compounds, saponins, phytates and oxalates are common among nun nutritive bioactive compounds. Cyanogenic glycosides are responsible for cassava toxicity, but can be found in some species of beans such as lima beans especially black varieties, which can induce respiratory distress when consumed in large amounts (Champ, 2016).

The under-utilized legumes, which have remarkable potential for commercial exploitation but exist ignored, offer a good scope in this situation. Accounts of essentially under-exploited pulses which await exploration for food, fodder, energy and industrial purposes have been documented (Kalidass and Mohan, 2012). Exploitation of underutilized wild legumes is an important approach to defeat the protein-malnutrition in developing countries (Kala and Mohan, 2010).

4. Non Nutritive Compound found in Pulses

There are number of non-nutritive compounds available in different pulses. Enzyme inhibitors, lectins, phytates, phenolic compounds, pytosterols and saponins are few of them. Protein inhibitors found in pulses are regularly inhibit lipases, proteases, amylases, phosphatases and glycosidase in the human body. Trypsin and chymotrypsin normally found in common beans that work against proteases. Trypsin and chymotrypsin are commonly available in Lima beans, cowpea, lentils and kidney beans. These non-nutritive compounds reduce the digestibility and bioavailability of nutrients during food digestion and absorption process.

Lectins or hemoglutenins damage the intestinal epithelium and influence on absorption of nutrients. Further lectins are responsible for reduce the bioavailability of minerals. They are commonly found in lentils, lima beans, kidney beans, pigeon peas and common beans. Phytosterols found in most of the pulses in the world are responsible to reduce the serum cholesterol level and alter the calcium activated potassium channel opener.

Tannins are potent in lowering the amino acid digestibility and increase the fecal nitrogen level. Pulses with dark color seed coats contain more tannins than pulses with light color seed coats. Amount of tannins found in pulses also depend on the level of maturation. Oligosaccharides including raffinose and stachyose, saponins and phytates are found in most of the pulses that reduce the digestibility of food and bioavailability of nutrients (Jain *et al*., 2009; Sing and Basu, 2012; Parca *et al*., 2018).

However, most of the non-nutritive substances found in pulses are potential antioxidants with anticancer properties, lowering cholesterol, reduce the risk of heart diseases, boost immunity of the body and so on. Negative impact of these non-nutritive compounds can be eliminated by soaking, cooking, steaming, fermenting, milling and hulling like unit operations.

5. Nutritional Composition Analysis of Food and its' Importance

With the development of chemistry, attention in the composition of food also ascended and the first food composition databases date back to the second half of the nineteenth century. In those times, sufficiency and appropriateness of the diet, principally with regard to macronutrients and minerals, were the focuses of food analysis, as most vitamins were only discovered later. Interestingly, natural variation in food composition was already being taken into account (Elmadfa and Meyer, 2010).

Data on the composition of foods are crucial for nutrition research, product development, nutrition education, trade of foods and food products between and within countries, estimating/comparing the nutrient content of foods, identifying sources of particular nutrients, analyzing individuals' diets, devising special diets for patients (e.g. heart disease, coeliac disease), analyzing dietary survey data, assessing how dietary intake affects health and disease outcomes, devising special diets for epidemiological research, monitoring food and nutrient availability, development of dietary guidelines, implementation and monitoring of food legislation, consumer information and education, preparing educational materials (e.g. for schools), food labeling and nutrient claims, marketing of products, recipe and menu development and analysis, devising special diets for healthy people with particular needs (e.g. athletes), completing missing values in a dataset, to assess overall dietary balance, to obtain a quantitative estimate of energy and/or specific nutrient intakes, to identify nutritional deficiencies or excesses, to assess the risk of malnutrition, to monitor compliance with dietary advice and development of nutrition and agricultural policies by government agencies (Rand *et al*., 1991; Williamson, 2005; Egan *et al*., 2007).

Food composition data have been compiled into many databases all over the world. As the uses of those data increase, a larger number of individuals and organizations become involved in their compilation, and thus the need for guidelines on their gathering, formatting, and documentation increases. These documents describe and present recommendations for the procedures involved with compiling the values for food composition databases and tables. There are five specifically addressed major ways to obtain data on the nutrient content of foods: direct analysis based on analytical measurements, calculated as representative values (e.g., weighted means of several samples), gathered from other sources (e.g. taken from other tables or the literature), estimated from similar foods (e.g. substitution of data) and estimated from ingredients (e.g. recipe calculations) (Williamson, 2005).

Several factors, many of which can barely be controlled, can impact food composition. Definitely, seasonal variation can be quite large for the content of micronutrients and bioactive substances in plant foods (Collomb *et al*., 2008). Regional disparities also occur. When considering a certain food as a source for a given nutrient, bioavailability is of importance but may be difficult to estimate if information about factors reducing or enhancing the bioavailability and the nutrients' chemical and binding forms are not available. Further, some nutrients can be derived in the body from precursors, such as vitamin A from provitamin A-carotenoids or tryptophan, so that the total amount provided by a food can be much higher than that for the more preformed nutrient. To take this into account, equivalents are used on the basis of the metabolism of the different forms. Vitamin A serves as an example with 6 mg of β-carotene and 12 mg of other vitamin A-active carotenoids, yielding 1 mg retinol (FAO/WHO, 2002).

Information on food composition is important for scientists and practitioners working in the fields of nutrition and public health. The most obvious role is to provide the basis for dietary valuation and the formulation of healthier diets. For the general population, food-based dietary guidelines are considered the best means to convey more comprehensible recommendations for food choice. Nutrition and health claims have to be supported by sound scientific evidence, including data on the food nutrient content of food. It is even more important when one or a group of specific nutrients have to be avoided or controlled for a pathological reason. Therapeutic nutrition may require additional data that are so far not widely available. This is also the case for bioactive compounds mainly found in plant foods that, in light of their different health effects, have recently gained the attention of scientific interest. Finally, data on contaminants and other potentially harmful compounds are also of public relevance to permit risk assessment. Against this background, there exists a strong need to harmonize existing data and collect new data on food composition (Elmadfa and Meyer 2010).

6. Conclusion

Pulses are a food category that gained more attention very recently. There are many health benefits of pulses and therapeutic effects of pulses are remarkable. Therefore, pulses are good sources of nutrients for the countries suffer from malnutrition, micronutrient deficiencies, obesity and diet related diseases. Nutritional composition of pulses are important for many concerns related to medical purposes, marketing, nutrition and scientific research based fields to upgrade the human food consumption and nutritional status (FAO,2016). There are number of lesser-known traditional pulses found in Sri Lanka. They were cultivated and consumed since the antiquity. It is very important to analyze the nutritional composition of Sri Lankan traditional pulses. Paying attention on exploitation of these pulses is essential to fulfill the protein and mineral requirements of the country (Helvetas, 2001).

References

Campos-vega, R., Loarca-piña, G. & Oomah, B.D. (2010). Minor components of pulses and their potential impact on human health. *Food Research International*, 43(2), pp.461–482. Available at: <http://dx.doi.org/10.1016/j.foodres>. Accessed on 4th September 2016.

Champ, M. (2016). Non-nutrient bioactive substaces of pulses, *British Journal of Nutrition*, 88(S3), 307-319.

Collomb M., Bisig, W., Bu¨tikofer, U., Sieber, R., Bregy, M. & Etter, L . (2008). Seasonal variation in the fatty acid composition of milk supplied to dairies in the mountain regions of Switzerland. *Dairy Science and Technology*, 88, pp.631–647.

Department of Census and Statistics, Sri Lanka.(2016). Extent and production of seasonal crops. Available at:

<http://www.statistics.gov.lk/agriculture/seasonalcrops/SeasonalCropsNational Totals.html> Accessed on 12th September 2017.

Egan, M.B.,Fragodt, A.,Raats, M.M., Hodgkins, C. & Lumbers, M. (2007). The importance of harmonizing food composition data across Europe. *Europoean Journal of Clinical Nutrition*, (61), 813–821.

El-amier, Y.A. & Abdullah, T.J. (2015). Evaluation of Nutritional Value for Four Kinds of Wild Plants in Northern Sector of Nile Delta , Egypt. *Open Journal of*

Applied Sciences, 5(July), 393–402.

Elmadfa, I. & Meyer, A.L. (2010). Importance of food composition data to nutrition and public health. *European Journal of Clinical Nutrition*, 64(S3), pp.S4–S7. Available at: <http://dx.doi.org/10.1038/ejcn>. Accessed on 2nd February 2016.

FAO, (2010). Storage and Processing of Roots and Tubers in the Tropics. Available at: <http://www.fao.org/docrep/x5415e/x5415e00.htm#Contents>. Accessed on 2nd September 2017.

FAO (Food and Agriculture Organization of the United Nations), (2013). Dietary protein quality evaluation in human nutrition. FAO Food and Nutrition Paper n.92.

FAO & WHO (Food and Agriculture Organization of the United Nations/World Health Organization). (2002). Human Vitamin and Mineral Requirements. Report of a Joint FAO/WHO Expert Consultation, Bangkok, Thailand. FAO, Rome, Italy.

FAO, (2016). FAO/INFOODS global food composition database for pulses, User Guide, Rome.

Grain, legume & oil crops research & development center, (2016). Agunakolapelessa, Sri Lanka

Grain research development corporation, Austrailia, 2008. Nutrition. Grain Legume Handbook.Ch 4.pp.4.1-4.12

Helvetas Sri Lanka, (2001). *Sustainable_Farming_System_book.pdf*, Helvetas Sri Lanka.pp. 1-137.

Heimler, D., Vignolini, P., Dini, M. G. & Romani, A. (2005). Rapid tests to assess the antioxidant activity of Phaseolus vulgaris L. dry beans. *Journal of Agriculture and Food Chemistry*, 53, 3053–3056.

Hoover, R., Hughes, T., Chung, H. J. & Liu, Q. (2010). Composition, molecular structure, properties and modification of pulse starches—A review. Food Res. Int. 43, pp. 399-413.

Jain.A.K., Kumar, S. & Panwar, J.D.S. 2009. Antinutritional factors and their detoxification in pulses- a review, *Agriculture Reviews*. 30 (1) : 64 - 70.

Jain, A.K. & Tiwari, P. (2012). Nutritional value of some traditional edible plants used by tribal communities during emergency with reference to Central India. *Indian Journal of Traditional Knowledge*, 11(January), 51–57.

Kala, B.K. & Mohan, V.R. (2010). Chemical Composition and Nutritional Evaluation of Lesser Known Pulses of the Genus , Mucuna. , 1(December), pp.105–116.

Kalidass, C. & Mohan, V.R. (2012). Biochemical composition and nutritional assessment of selected under-utilized food legume of the genus Rhynchosia. *International Food Research Journal*, 19(3), 977–984.

Mai, B., (1994). Underutilized Grain Legumes and Pseudocereals. Their potentials in Asia. RAPA Publication, FAO, Bangkok. pp. 162.

Madhujith, T., Naczk, M., & Shahidi, F. (2004). Antioxidant activity of common beans (*Phaseolus vulgaris* L.). *Journal of Food Lipids*, 11, 220–233.

Misra, S. & Misra, M.K. (2016). Ethnobotanical and Nutritional Evaluation of Some Edible Fruit Plants of Southern Odisha , India. *International Journal of Advances in Agricultural Science and Technology*, 3(1),1–30.

Modi, M. (2009). The nutritional quality of tradi tional and modified traditional foods in kwazulu-natal. Master's thesis of Agriculture (Food Security), Faculty of Science and Agriculture, University of KwaZulu-Natal, Pietermaritzburg, Africa. 2, pp. 7-23.

Mubarak, A. E. (2005). Nutritional composition and antinutritional factors of mung bean seeds (Phaseolus aureus) as affected by some home traditional processes. *Food Chemistry*, 89, pp. 489–495.

Muthukuda Arachchi, D.H. & Wijerathne, P.M. (2007). Country Report On The State Of Plant Genetic Resources For Food And Agriculture, Department of Agriculture, Sri Lanka.1, 11-15.

National Geographic Society, (2017). monsoon. National Geographic Society. Available at: <https://www.nationalgeographic.org/encyclopedia/monsoon/ > Accessed 14th December 2017.

Ndango, R. (2013). Nutritional Evaluation Of Five African Indigenous Vegetables. *Journal of Horticulture Research*, 21(1), 99–106.

Ofuya, Z. M. & Akhidue, V, J. (2005). The Role of Pulses in Human Nutrition. Applied Science &. Environment Management, 9(3), pp. 99 – 104.

Parca, F., Koca, Y.O. & Unya, A. (2018). Nutritional and Antinutritional Factors of Some Pulses Seed and Their Effects on Human Health, I*nternational Journal of*

Secondary Metabolite,5(4), 331-342.

Phillips, K.M., Pehrsson, P.R. & Agnew, W.W. (2014). Nutrient composition of selected traditional United States Northern Plains Native American plant foods. *Journal of Food Composition and Analysis*. 34, 136-152.

Rajapaksha, U. (1998). Traditional Food Plants in Sri Lanka, Traditional Food Plants in Sri Lanka.pp. 1-15.

Rand, W.M., Pennington, J.A.T.,Murphy, P. & Klensin, J.C. (1991). Compiling Data for Food Composition Data Bases. , pp.1–65.

Sing, A. & Basu, P.S. (2012). Non-Nutritive Bioactive Compounds in Pulses and Their Impact on Human Health: An Overview, *Food and Nutirion*, 3, pp. 1664-1672.

Siriweera, I., (1993). Sri Lankawe Krushi Ithihasaya (till 1500 A.D.). S.Godage and Brothers, Colombo. pp.9-29.

Trugo, L. C., Farah, A. & Trugo, N. M. F. (1993). Germination and debittering lupin seeds reduce a-galactoside and intestinal carbohydrate fermentation in humans. *Journal of Food Science*, 58, 627–630.

Williamson, B.C. (2005). Synthesis report No 2 : The Different Uses of Food Composition Databases. , (2).pp.2-27.