Nutrient analysis of local pumpkin varieties (*Cucurbita* spp.) grown in dry zone of Sri Lanka and development of a value-added product

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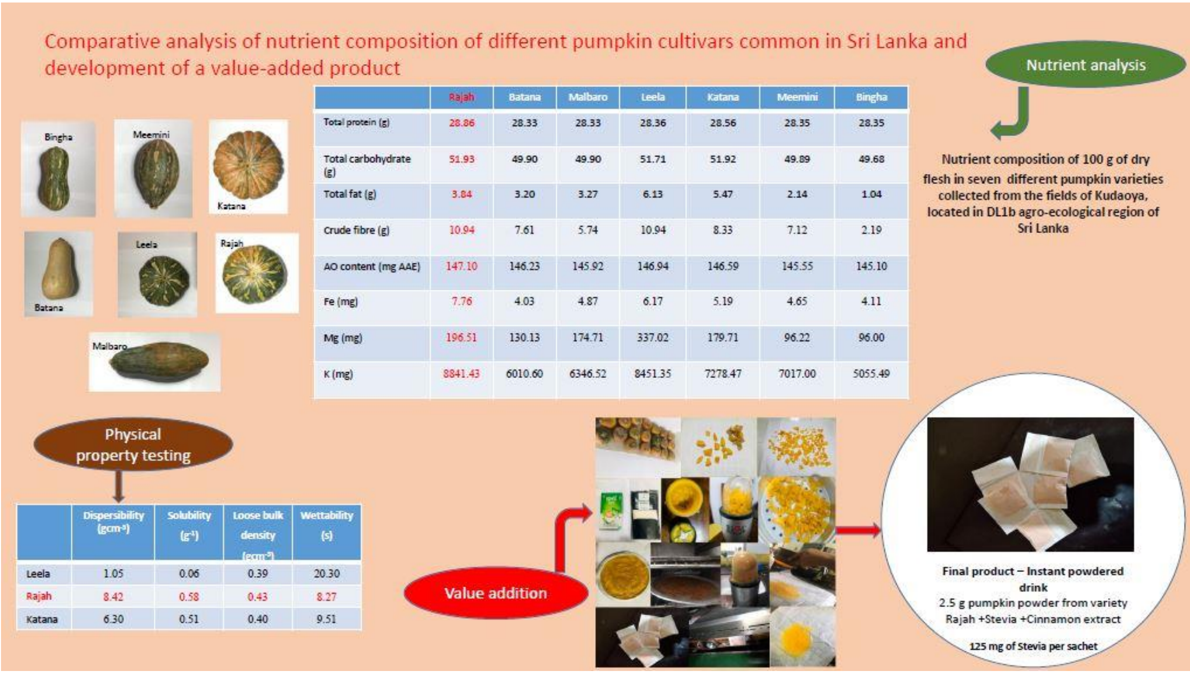
Date Received: 07-04-2023 Date Accepted: 17-05-2023

Graphical Abstract



Abstract

Cucurbita spp. generally recognized as pumpkins in Sri Lanka, is a commonly grown vegetable in the dry and intermediate zones in the island. *C. maxima* and *C. moschata* are the highly popularized cucurbits and they include number of varieties including open pollinated varieties (OPVs), hybrid and imported varieties. The study was aimed to conduct a nutrient analysis of 7 pumpkin varieties collected from dry zone low country 1b (DL1b) agro-ecological region of Sri Lanka and development of a value-added product considering the nutrient composition of the varieties. The proximate, mineral composition and the antioxidant activity were evaluated using standard analytical methods and compared the varieties through one-way ANOVA. According to the study results in 100 g of pumpkin flesh powder, protein content was ranging from 28.33-28.86 g, carbohydrates from 49.68-51.93 g, fat content from 1.04-6.13 g, crude fibre from 2.19-10.94 g, Fe content from 4.11-7.76 mg, K content from 5055.49-8841.43 mg, Mg content from 96.0-337.02 mg and antioxidant activity from 145.10-147.10 mg AAE (Ascorbic acid equivalent) in the analysed pumpkin varieties in dry weight (DW) basis at 95 % confidence interval. As per results, the three varieties of *C. maxima* have expressed significantly higher values ($p<0.05$) during the nutrient analysis compared to the *moschata* varieties. For the development of the instant powdered drink as the value-added product, 'Rajah' which is a *C. maxima* variety was used considering its nutrient richness over the other tested varieties and due to its significantly higher ($p<0.05$) dispersibility (8.42 gcm^{-3}), solubility (0.58 g), loose bulk density (0.43 gcm^{-3}) and low wettability (8.27 s). Considering the overall acceptability rated as 3.80 out of 5 from the sensory evaluation, the instant drink made by supplementing cinnamon extract and stevia in 1:1 was finalized as the value-added product. The knowledge on the compositional and physical property variation among different varieties of pumpkin and the value addition information of pumpkin would be useful in future value additions which emphasize products' nutritional and nutraceutical parameters.

Key words: *Cucurbita* spp., *Dry zone low country, Sri Lanka, Nutrient analysis, Value addition*

1. Introduction

Pumpkins, scientifically named as *Cucurbita* spp. (2n=2x=40), which belongs to the family *Cucurbitaceae* and the genus *Cucurbita*, is a popular vegetable across the world including temperate, sub-tropical and tropical countries. In addition to that, it is a highly consumed and cultivated crop due to its high yield, adaptability to wide range of climatic conditions, long storability and high nutritional value (Jesmin et al., 2016). In the genus *Cucurbita*, there are three main economically important pumpkin species as *C. maxima*, *C. moschata* and *C. pepo* which are extensively cultivated worldwide (Ekanayaka, 2019). In pumpkins, the fruits including the seeds, pulp, flesh and peel and also the flowers and tender leaves are being consumed since the early domestication period of this crop due to the importance of them in folk medicine and addressing various dietary concerns like Vitamin A deficiency, Fe deficiency and many other micronutrient deficiencies (Salehi et al., 2019).

In Sri Lanka, pumpkins are cultivated mainly in the areas of dry and intermediate zones targeting the *Maha* season compared to the *Yala*, due to the favourable climatic conditions in this season. Annual production of pumpkin in Sri Lanka is estimated to be 20,00-40,000 metric tons where more than 20% of the production is wasted due to the imbalance between production and the consumption and due to the poor post-harvest practices. Monaragala, Anuradhapura, Rathnapura, Hambanthota, Mahaweli system H and Mathale have been identified as the areas with highest cultivation (Pushpakumari et al., 2013). According to the Department of Agriculture (DOA) in Sri Lanka, there are diverse pumpkin varieties which are currently grown in Sri Lanka, belongs to the *C maxima* and *C. moschata*. But *C. pepo* is not much popularized within Sri Lanka compared to the other two varieties. Arjuna, ANK Ruhunu, Meemini, Rajah, Katana, Bingha, Pathma, Butternut, Leela, Lanka, MK Spanchy, Samson, Goldma. Cheonlima, Shiba are some of the varieties which are cultivated in Sri Lanka (Ekanayaka, 2019). These varieties include hybrid varieties, improved varieties, imported varieties and open pollinated varieties (OPVs). Out of the commonly cultivated varieties, only Pathma and ANK Ruhunu have released by the Department of Agriculture in Sri Lanka (Department of Agriculture, 2022).

Morphological characteristics are highly diversified among the pumpkin species and varieties mainly in their leaf characteristics, fruit shape, size, colour, flesh characteristics, seed number and seed characteristics (Hosen et al., 2021). In addition, the variation of nutrient composition in different Pumpkin varieties and in different parts of the same variety has been reported in several research studies (Amin et al., 2019; Blessing, et al., 2011; Hashash et al., 2017; Hussain and Jamil, 2021). However, in Sri Lanka, such comparative studies which identify the morphological differences and nutrient composition differences in different pumpkin varieties are not available. Therefore, this study will provide a potential insight about the changes in the nutritional composition of different indigenous and imported hybrid pumpkin varieties which are dominantly been cultivated in the dry zone of Sri Lanka.

Since pumpkin has been recognized as a crop with a higher post-harvest loss and with a remarkable nutrient and bio-active composition, as stated in Hosen et al. (2021), several studies have been carried out to develop certain value-added products which would be an effective waste and post-harvest loss management strategy. Additionally, value addition increases the market value of the raw pumpkins which would be economically beneficial to the producers. Mainly pumpkin flour has been tested for its effectiveness as a substitution for wheat flour in several bakery products as biscuits, cookies, bread, cake, muffins, extruded snacks (Arachchige et al., 2019; Jesmin et al., 2016; Kumari et al., 2019, 2020; Khan et al., 2019). In addition, value addition of pumpkin has been extended to produce diverse products such as ready to serve drinks, jams, jellies, pickle, sweets etc. mainly due to the sweetness, aroma, characteristic colour in fruit, physical properties and chemical composition of pumpkins (Jesmin et al., 2016). However, in Sri Lanka production of value-added products using pumpkins is not popularized. Therefore, this study will create a novel approach of developing value-added products using pumpkins considering its beneficial nutrient composition.

In this study, a nutrient analysis was conducted to detect the proximate composition, mineral composition (Fe, K and Mg) and antioxidant activity of fruit flesh in seven different local pumpkin varieties belongs to *C. maxima* and *C. moschata*, collected from Kudaoya, Monaragala District in Sri Lanka. Along with that, as a part of this study, from using a pumpkin variety with compatible physical properties, an instant powdered drink was developed as a value-added product and evaluated its sensory attributes and the consumer acceptance.

2. Methodology

2.1 Sample collection

Seven different pumpkin varieties (Plate 1) were collected from the fields located within 5 km range from the Kudaoya town (6° 58' 50" N, 81° 3' 46" E), which is located in Monaragala District of the Uva province belongs to DL1b agro-ecological region. All the varieties have collected from the fields at their fullest harvestable maturity. For the accuracy of the analysis, four fruits from each variety in same maturity level were collected. Information about the seed source of each variety was gathered according to the farmers and the morphological characteristics of the varieties were obtained through field observations.

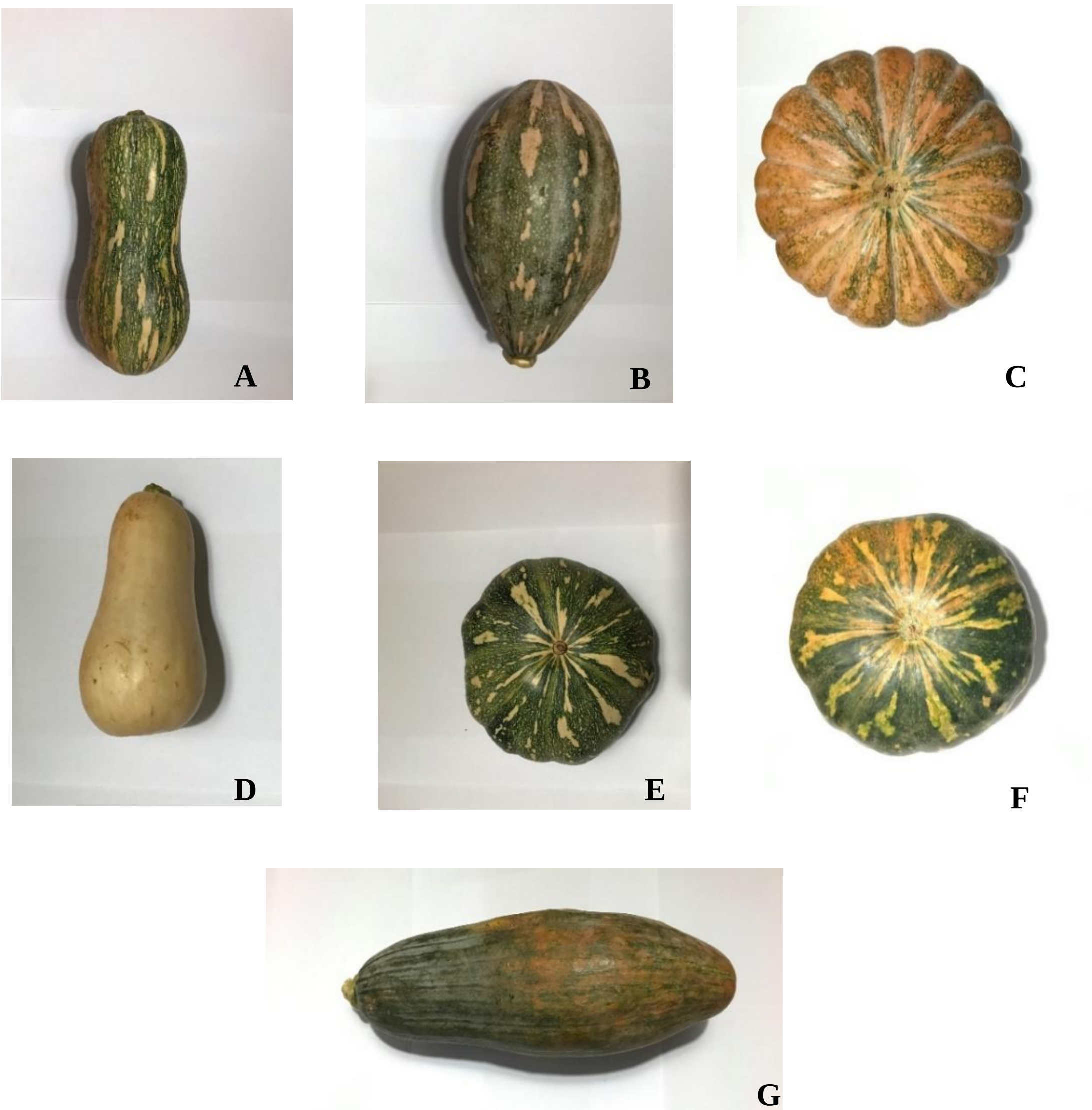


Plate 1: Different pumpkin varieties collected from the areas in Kudaoya located in Monaragala District, Sri Lanka; A-Bingha, B-Meemini, C-Katana, D-Batana, E-Leela, F-Rajah, G-Malbaro

2.2 Sample preparation

Pumpkins were washed and removed the peel and seeds. Next, the pulp and the flesh parts were separated. Then the cut flesh part was subjected to steam blanching for 2-3 min. The blanched pumpkin samples were then dried using the hot air oven (Stuart Scientific, England) at 50 ^{0}C temperature until become suitable for the grinding process considering the physical texture of the dried material. After drying, the samples were pulverized into a fine powder using a grinder (MAGIC Bullet, NH-21pcs, Teleseen) and sieved from a sieve with 300-micron mesh size.

Prepared powder of each variety was stored in air-tight zip lock bags and kept under room temperature until the samples were used in the nutrient analysis and further evaluations.

2.3 Nutrient analysis

2.3.1 Proximate analysis

Total protein content, total carbohydrate content, total fat content, and crude fibre content were evaluated under the proximate analysis. Total protein content was quantified by the Bradford method (Bradford, 1976) at 595 nm using the UV-Visible spectrophotometer (CT-8200, Chrom Tech, USA). For the analysis, 30.0 mg of pumpkin powder was dissolved in 10.0 ml of distilled water and120 µl from that was mixed with 1880 µl of Bradford reagent to measure the absorbance.

Total carbohydrate content in the flesh of pumpkin fruit was determined by the phenol-sulphuric method as described by Nielsen (2003) at 490 nm using the UV-Visible spectrophotometer. For the analysis 20.0 mg of pumpkin powder was used and the amount was dissolved in 10.0 ml of distilled water. After that 1.0 ml of the supernatant of this solution was mixed with 1.0 ml of 5 % phenol and 5 ml of concentrated sulphuric acid. Then the resulted solution was heated for 5 min at 100 0C and again vortexed for 30 seconds. Finally, 1.0 ml of the final solution was mixed with 2.0 ml of distilled water and measured the absorbance.

Total fat content determination was done according to the Bligh and Dyer method as described by Bligh and Dyer (1959). For the analysis, 5.0 g of powdered samples were used. It was then mixed with 10.0 ml of distilled water, 20.0 ml of chloroform and 20.0 ml of methanol as the solvent ratio makes 1.8: 2: 2 accordingly. Then the filtrate was centrifuged for 8 min at 4000 rpm. After that, the upper alcohol aqueous layer was aspirated and the remaining chloroform layer with dissolved fat was dried at 105 ^{0}C for 1 hour and 50 min using a drying oven to evaporate the solvent. Finally, the final weight was obtained and calculated the fat content.

Crude fibre analysis was done according to the AACC method No. 32-10.01. For the analysis 1.0 g of pumpkin powder was used. The results of the proximate analysis were reported as values per 100 g of pumpkin flesh in DW (Dry Weight) basis.

2.3.2 Total antioxidant activity assessment

Total antioxidant activity in pumpkin flesh in DW basis was determined by FRAP (Ferric Reduction Antioxidant Power) assay as described in Vijayalakshmi and Ruckmani (2016) at 700 nm using the UV-Visible spectrophotometer. Total antioxidant activity as Ascorbic acid equivalent (AAE) in 100 g of pumpkin flesh in different varieties was reported in DW basis.

2.3.3 Mineral analysis

Fe, Mg and K contents of pumpkin flesh in DW basis were determined through AAS (Atomic absorption spectroscopy) method. Sample preparation for the AAS analysis was done according to the dry ashing method, described in Perkin Elmer Coorporation (1996).

2.4 Development of the value-added product

A self-reported questionnaire survey was conducted with the aim of identifying the preference for pumpkin consumption, preference for a value-added product developed from a pumpkin variety and suggestions for a value-added product to be developed, using a Sri Lankan government University population including students, academic and non-academic staff and labourers with 400 random, volunteer participants. Based on the data, collected from the questionnaire survey, the type of value-added product which would be developed under the product development section, was determined.

The approval to conduct the self-reported questionnaire survey with human participation, was received by the Ethics Review Committee (ERC) of Faculty of Medical Sciences, University of Sri Jayewardenepura, Sri Lanka.

2.4.1 Physical property testing

Physical properties which have recognized as important to be in a powdered drink product, according to Belsack-Cvitanoic *et al*. (2010), were tested by using pumpkin powders of three varieties with highest nutritional composition; Rajah, Leela and Katana. Dispersibility, solubility, wettability, and loose-bulk density of the pumpkin powders in selected varieties were evaluated.

2.4.2 Product development

For the development of the instant powdered drink as the value-added product from pumpkin, ‘Rajah’ variety was selected considering the results of nutrient analysis and physical property analysis. Figure 1 displays the value addition process of the raw pumpkins into an instant powdered drink as the end product. Under this ‘Rajah’ pumpkins were washed with normal tap water and removed its peel, pulp, and the seeds. The flesh part was separated and cut into small pieces using a regular vegetable cutter. Then the cut pieces were steam blanched for 3 min. After that the blanched content was ground using a grinder (MAGIC Bullet, NH-21pcs, Teleseen), into a puree and this was done without adding water. As the preservative agent for the developing product, potassium sorbate was selected. The final product was designed as it includes 500 mg of potassium sorbate in 1 kg of puree (Food act, No 26 of 1980 in Democratic Socialist Republic of Sri Lanka).

After that the puree was divided into five equal portions of 200.0 g and denoted by a random three-digit number. According to the information included in the Table 1, cinnamon extract and stevia were added to those separate portions of prepared pumpkin puree in respective amounts to make five different drink categories. Cinnamon extract was prepared by boiling 25.0 g of fresh cinnamon bark with 200.0 ml of drinking water, until the volume reduced into half. Stevia was selected as the sweetener since it contains fewer calories than table sugar, which makes the final product more suitable for the individuals with certain dietary and health conditions. Stevia solution was prepared by dissolving 50.0 g of commercially available stevia powder in 100.0 ml water. Amount of stevia added was determined according to the FDA guidelines as it is safer to consume by the individuals whose bodyweight is over 31 kg. Finally, the prepared puree types were subjected to the powdering process. Samples were dried in the laboratory drying oven (OV 67/350-67L, SCO Tech, Germany) at 45 ^{0}C for 30 hours. After the drying of the pumpkin samples, they were taken out from the trays and pulverized by using a grinder into powder and sieved through a 300-micron mesh sized sieve.

Table 1: Added combinations of cinnamon extract and stevia, into 200.0 g of pumpkin puree fractions during the instant powdered drink production.

Drink category	Added amount of Cinnamon extract /ml	Added amount of Stevia / ml
461	0	0
593	0	20
325	20	20
101	20	40
227	20	0

2.4.3 Sensory evaluation

Sensory evaluation was performed as described by Sidel et al. (1981) with the participation of 30 panellists. During the evaluation, five instant powdered drink categories as described in the product development section, were evaluated for their overall acceptability using a 5-point hedonic scale and for their impression about the product at purchasing in future.

2.4.4 Product finalization

Sample drink category which was denoted by ‘325’ was finalized as the value-added instant powdered drink. The pre-prepared powder from this category was included in a sachet made up of food grade paper and fibre, as one sachet includes 2.5 g of pumpkin powder with 125 mg of Stevia. Then this package with pumpkin powder was sealed by a continuous band sealer (FR-900, Unipack Technology Services, Sri Lanka).

2.5 Data analysis

All experiments were carried out with four replicates from each variety. Replicates were subjected to same experimental conditions and obtained a separate value as the final result to calculate the mean value. Data analysis was done by MS office Excel 2016 and Minitab Statistical Software (Minitab 20). The statistical analysis of the nutrient composition and the physical properties of the pumpkin powders was done through Minitab 20. Results of the study were expressed as mean ± SD (Standard Deviation). The analysis was done using one-way ANOVA (Analysis of variance) with 0.05 level of significance and at 95 % confidence interval.

Figure 1: Production process of the instant powdered drink as the value-added product from the variety Rajah; A- raw pumpkins, B- separating the fruit flesh, C- size reduction of the flesh part, D- steam blanching, E- grinding process, F- prepared pumpkin puree, G- added sweetener (Stevia) and the preservative agent (potassium sorbate), H- spreading the puree on a drying tray, I- puree after drying, J- pulverizing the dried puree, K- sieving the pulverized sample through a 300-micron sieve, L- resulted pumpkin powder, M- sealing the package using the continuous band sealer, N- instant powdered drink as the value added product.

3. Results and Discussion

The results of the proximate analysis in different pumpkin varieties are presented in Table 2. According to the results, a significant difference of protein, carbohydrate, fat, and crude fibre contents has identified among the seven pumpkin varieties. In the analysis of total protein content, highest value was reported by Rajah and the lowest value was reported by Batana and Malbaro. Rajah was recognized as the variety with the highest total carbohydrate content. In addition to that all seven varieties have exhibited their protein and carbohydrate content within a narrow range, closer to the value of Rajah. But in the consideration of the total fat and the crude fibre content in different varieties, the values were obtained within a broader range as 1.04-6.13 g of total fat and 2.19-10.94 g of crude fibre accordingly in all tested varieties.

Table 2: Proximate composition of 100 g of pumpkin flesh in DW basis

Variety	Nutrient Parameter			
	Protein (g)	Carbohydrate (g)	Fat (g)	Crude fibre (g)
Rajah	28.86 ± 0.06^{a}	51.93 ± 0.21^{a}	3.84 ± 0.05^{c}	10.94 ± 0.05^{a}
Batana	28.33 ± 0.03^{d}	49.90 ± 0.35^{cd}	3.20 ± 0.07^{d}	7.61 ± 0.07^{c}
Malbaro	28.33 ± 0.03^{d}	49.90 ± 0.34^{c}	3.27 ± 0.10^{d}	5.74 ± 0.05^{e}
Leela	28.36 ± 0.03^{c}	51.71 ± 0.25^{b}	6.13 ± 0.09^{a}	10.94 ± 0.05^{a}
Katana	28.56 ± 0.04^{b}	51.92 ± 0.35^{a}	5.47 ± 0.09^{b}	8.33 ± 0.05^{b}
Meemini	28.35 ± 0.01^{c}	49.89 ± 0.33^{d}	2.14 ± 0.10^{e}	7.12 ± 0.03^{d}
Bingha	28.35 ± 0.02^{c}	49.68 ± 0.33^{e}	1.04 ± 0.11^{f}	2.19 ± 0.05^{f}

Values are indicated as mean ± SD (n=4). Means with different letters as a superscript in same column are significantly different at $p<0.05$.

The values obtained for the proximate composition during this study was higher than the results, reported by Amin et al. (2019) conducted to identify the proximate composition of peel, flesh and seed powders of indigenous and hybrid pumpkin varieties in Bangladesh. Values obtained for crude fibre, fat, protein and carbohydrate of this study are higher than the results reported by Hussain et al. (2021), where the proximate composition of C. *pepo* in Egypt was evaluated. However, reported values for the protein and carbohydrate contents in this study are significantly lower compared to the values reported by Malkanthi and Hiremath (2020), which was done evaluating the pumpkin pulp powder, prepared from pumpkins collected from Bengaluru, India. The reported values for crude fibre and fat in Sri Lankan varieties from this study have shown a significant dominance over the values reported in the study conducted in India. In addition to that, the study results have shown a disagreement with a study conducted by Ngozi-Franca, 2013, in Nigeria. In this study, they have done a comparative analysis for different cucurbits including snake gourd, cucumber, and pumpkins. According to the results, Sri Lankan pumpkin varieties were recognized with characteristic fibre and fat content over those cucurbits.

According to Amin et al. (2019), the proximate composition is extremely variable, basically due to the genetic differences among the varieties and species, environmental factors of the cultivating areas. The results can be different, due to the differences of the analytical methods. During the proximate analysis of this study, protein analysis was done through Bradford method which was a colorimetric method. As mentioned in Colyer and Walker (1996), this method is a fast and accurate protein quantification method with less interference of non-protein components in analysing samples. But as the major drawback of this method, the high specificity of Coomassie Blue towards arginyl and lysyl protein residues was reported. Total carbohydrate content was measured by the phenol-sulphuric method, again which was a colorimetric method. As described in Dubois et al. (1951), this method is a rapid, inexpensive and accurate carbohydrate quantifying method with high reproducibility. During the proximate analysis, the fat content of the pumpkin samples was determined by Bligh and Dyer method, which has identified as a standard lipid isolating method from the biological samples and other samples. However, the method has been identified as less sensitive in the analysis of samples with high lipid contents, specially consist of high amounts of neutral lipids (Eggers, 2020). Since pumpkin is considered as a vegetable with low fat, this method was used in the fat quantification process.

Results of the antioxidant activity in different pumpkin varieties obtained during the nutrient analysis are presented in the Table 3. All seven pumpkin varieties have shown a significant difference ($p<0.05$) in their antioxidant activity ranging from 147.10-145.10 mg AAE/100g in DW basis. The highest antioxidant activity was reported in Rajah which is a *C. maxima* variety and the lowest value was reported in Bingha which is a *C. moschata* variety. Second and third highest ranking varieties are also *C. maxima* varieties which are Leela and Katana. Similar pattern of antioxidant activity variation was observed in a study conducted by Zhou et al. (2017), during the comparison of antioxidant activity of *C. maxima*, *C. moschata* and *C. pepo*.

Table 3: Total antioxidant activity (mg AAE) in 100 g of pumpkin flesh in DW basis

Rajah	Batana	Malbaro	Leela	Katana	Meemini	Bingha
147.10 ± 0.02^{a}	146.23 ± 0.04^{d}	145.92 ± 0.03^{e}	146.94 ± 0.03^{b}	146.59 ± 0.01^{c}	145.55 ± 0.02^{f}	145.10 ± 0.03^{g}

Values are indicated as mean ± SD (n=4). Means with different letters as a superscript are significantly different at $p<0.05$.

Antioxidant activity in pumpkin samples was measured by FRAP assay which is a redox-linked colorimetric method that directly quantifying the antioxidant power of a sample. This method is a rapid, inexpensive, highly reproducible quantification method (Benzie and Strain, 1996). In this method, Fe^{3+} are being reduced by the antioxidant molecules present in the samples. As reviewed in Munteanu and Apetrei (2021), most recently potassium ferricyanide (KFCN) has been used as the ferric reagent in the modified version of FRAP test and that modified version was used in the antioxidant activity measurement during the study. The values are presented as mg AAE, since the results have obtained relative to the Ascorbic acid.

Results of the mineral composition including Fe, K and Mg in different pumpkin varieties are presented in Table 4. According to the results, analysed pumpkin varieties have shown a significant difference ($p<0.05$) regarding the analysed mineral types during the study. As per results, K was the most abundant mineral and Fe was the mineral with lowest amount in all seven pumpkin varieties. Considering the Fe content, Rajah was reported with the highest value while the Batana was reported with the lowest value. Considering the K content, again Rajah was reported with the highest value and Bingha with the lowest value. Considering the Mg content, Leela was reported with the highest value and again Bingha with the lowest value. For all three types of minerals, *C. maxima* varieties including Rajah, Leela and Katana had the highest results compared to the *moschata* varieties following the same pattern as in the proximate analysis and in the antioxidant activity determination.

Similar results in the mineral abundance have observed in a study conducted by Amin et al. (2019) with highest K and lowest Fe contents in the pumpkin pulp powders of hybrid and indigenous varieties in Bangladesh. But the values respective to the analysed minerals reported in that study is lower than the results obtained during the analysis of Sri Lankan pumpkin varieties. In addition, the research results of Fe and K contents are in accordance with the results reported by Blessing et al. (2011), during a comparative study conducted by analysing 10 pumpkin accessions available in Nigeria.

Table 4: Mineral composition of 100 g of pumpkin flesh in DW basis

Variety	Mineral composition (mg/100 g)		
	Fe	K	Mg
Rajah	7.76±0.00^{a}	8841.43±0.21^{a}	196.51±0.04^{b}
Batana	4.03±0.00^{g}	6010.60±0.35^{f}	130.13±0.00^{e}
Malbaro	4.87±0.00^{d}	6346.52±0.35^{e}	174.71±0.00^{d}
Leela	6.17±0.00^{b}	8451.35±0.25^{b}	337.02±0.00^{a}
Katana	5.19±0.00^{c}	7278.47±0.35^{c}	179.71±0.04^{c}
Meemini	4.65±0.00^{e}	7017.00±0.59^{d}	96.22±0.01^{f}
Bingha	4.11±0.00^{f}	5055.49±0.49^{g}	96.00±0.00^{g}

Values are indicated as mean ± SD (n=4). Means with different letters as a superscript in same column are significantly different at $p<0.05$.

In order to develop a value-added product with consumer acceptance considering the consumer suggestions and preferences, a questionnaire survey was conducted. Data obtained from the questionnaire survey was used to evaluate the preference of pumpkin consumption by the community, preference for trying a value-added product from pumpkin and also to evaluate the product type which is mostly preferred by the community. Under the question 'Do you prefer eating pumpkin?', the participants were asked to mark their preference for consuming pumpkin. According to the results, 183 participants out of 400 were recognized in the 'Like' category, where 62 participants in the 'Very like' category. The no. of participants who marked the response in the 'Strongly dislike' category was null. These results were indicating that the majority of the community would accept a value-added product developed from pumpkin since > 50 % of the participants were preferred eating pumpkin. Under the question 'Do you prefer trying a value-added product developed from a specific pumpkin variety found in Sri Lanka?', participants were asked to mark their preference for trying a value-added product developed from pumpkin. According to the results, 379 out of 400 participants marked their preference for trying a value-added product which confirmed the assumption made in the above question. Under the question 'What type of value-added products would you prefer?', the participants were asked to record their suggestions about value-added products which should be developed from a pumpkin variety. According to the survey results, instant pumpkin drink was preferred by most of the respondents (119 out of 379) over the other product types. Other preferred product types by the participants were biscuits, soups, chips, and muffins from pumpkin. By having the community suggestions about the developing product, it would facilitate the product marketing and the generalizing the product in future. In addition to that, it would validate the necessity of the developing a product by filling the gap between the crop production and the consumer requirement.

During the analysis of powder properties, physical properties that would affect the suitability of pumpkin powders in developing an instant powdered drink were tested according to a study conducted by Belsack-Cvitanovic et al. (2010), which was evaluating the physical properties of powdered mixtures and drinks prepared with cocoa. According to that, solubility, dispersibility, wettability and loose bulk density of the pumpkin powders were tested. For this part of the study, the three varieties belong to *C. maxima* were used since they have recognized as the varieties with the highest nutrient composition. The varieties included Rajah, Leela and Katana. Results of the physical property analysis in three different pumpkin varieties are presented in Table 5. All four physical properties tested in the powders from different varieties have shown a significance difference ($p<0.05$).

Table 5: Variation of the physical properties of pumpkin powders made from different pumpkin varieties.

Variety	Physical property			
	Dispersibility (gcm^{-3})	Solubility (g^{-1})	Loose bulk density (gcm^{-3})	Wettability (s)
Leela	1.05 ± 0.13^{c}	0.06 ± 0.00^{c}	0.39 ± 0.00^{c}	20.30 ± 0.03^{a}
Rajah	8.42 ± 0.10^{a}	0.58 ± 0.00^{a}	0.43 ± 0.00^{a}	8.27 ± 0.02^{c}
Katana	6.30 ± 0.18^{b}	0.51 ± 0.00^{b}	0.40 ± 0.00^{b}	9.51 ± 0.02^{b}

Values are indicated as mean ± SD (n=4). Means with different letters as a superscript in same column are significantly different at $p<0.05$.

Considering the dispersibility, the values were expressed as a density measurement and the highest dispersibility was exhibited by Rajah, where the least dispersibility was exhibited by Leela. According to the study results, dispersibility in different pumpkin powders were ranging from around 1-6 gcm^{-3} and this values were in accordance with the values reported by Belsack-Cvitanovic et al. (2010), in a study conducted with cocoa powder. Considering the results obtained for solubility, same pattern was observed as in the dispersibility variation. Similar results were reported by the Belsack-Cvitanovic et al. (2010) also, indicating that the solubility and dispersibility has a strong correlation where solubility increases with higher dispersibility values. Variety 'Rajah' has expressed the highest solubility at 30 ^{0}C where variety 'Leela' exhibited the least solubility level. Compared to the results of the solubility in cocoa powder reported by Belsack-Cvitanovic et al. (2010), pumpkin powders have shown a higher solubility levels. However, solubility values reported from this study for different pumpkin varieties were slightly lower than the values reported by the Akther et al. (2020). In this study they have reported the solubility variation of mango powder under different drying methods and the results of this study were higher than the solubility values obtained regarding the pumpkin varieties. According to the results obtained for the loose bulk density, the highest density was reported by Rajah, where the least density was reported by Leela. The values were ranging closer to 0.4 gcm^{-3} and similar results were reported by the Belsack-Cvitanovic et al. (2010) for the tested cocoa powder. As described by Barbosa-novas and Juliano (2005), loose bulk density of a powder is an important parameter, which determines the size of the container and the strength of the reconstituted food, if the powder is utilized according to a given volume. Considering the wettability of the powders, the values were obtained ranging from around 8 to 20 seconds. The highest wettability time was exhibited by Leela, where the lowest time was reported in Rajah. If the wettability time is higher, that indicates that the powder will require more time to get dissolve in the medium. Therefore, for an effective powdered drink product, powders with low wettability time are preferred. According to the reported results of the study done by Belsack-Cvitanovic et al. (2010), the values obtained for the wettability in pumpkin varieties were considerably lower than the values of cocoa powders with different fat contents. Reported values for the tested properties in three pumpkin powders confirmed that 'Rajah' is the variety with favourable powder properties which made that the potential variety to use in the product development. The powder from this variety has shown the highest dispersibility, solubility and loose bulk density with the lowest wettability time compared to the other two *C. maxima* varieties.

Out of different types of sensory evaluation tests including descriptive tests, discrimination tests and affective tests, affective test type was selected to conduct the sensory evaluation of the developed instant powdered drink types according to Sidel et al. (1981). This type of study is conducting to evaluate the consumer acceptance and the preference for a specific product via a hedonic scale with 25-50 participants. For the sensory evaluation of the 5 types of instant powdered pumpkin drinks, 5-point hedonic scale and 30 participants were used.

The results of the evaluation finalized the product that would be developed as the value –added product from pumpkin considering the product sensory parameters like colour, aroma, texture etc. to assign the level of overall acceptability respective to each product category. During the data analysis, the used 5-point hedonic scale was converted into marking scheme from 1-5 where 1 was given for ‘dislike very much’ category and 5 was given for ‘like very much’ category. The results regard to the overall acceptability of the evaluated drink types are presented in Table 6. According to the results of the sensory evaluation, product denoted by ‘325’ had a significant difference in the overall acceptability compared to the other categories. Other four types of drinks failed to express a specific significant difference in overall acceptability. The ‘325’ was the product combination, where 1:1 ratio of cinnamon extract and stevia were used. This drink has expressed 3.8 overall acceptability which lies between ‘Neither like nor dislike’ category and ‘Like’ category but closer to the ‘Like’ category.

Table 6: Overall acceptability of the evaluated 5 pumpkin drink categories; denoted as a random three-digit number during the sensory evaluation.

Parameter	461	593	325	101	227
Overall acceptability	2.67 ± 0.78^{d}	3.07 ± 0.64^{bc}	3.80 ± 1.03^{a}	3.13 ± 0.94^{b}	2.53 ± 0.73^{cd}

Values are indicated as mean ± SD (n=30). Means with different letters as a superscript are significantly different at $p<0.05$.

Food action rating test has been carried out to evaluate the impression of the consumers to purchase the product in future based on the experience they had. During the analysis of food action rate, it did not specify a drink category and the respondents were asked to mark their opinion on future purchase considering the most preferred drink by them. According to the results, 18 respondents out of 30 (>50 %) has expressed their opinion in the category indicating that they would consume the preferred product very often. The results obtained during this section would be important in generalizing the developed product and in making further developments to this basic version.

4. Conclusion

The results of the nutrient analysis have indicated that the tested three varieties of *C. maxima* had a comparatively higher nutrient composition with higher protein, carbohydrate, fat, mineral and crude fibre content with higher antioxidant activity than the tested four varieties of *C. moschata* irrespective to their variety type as hybrid, imported or OPVs. An instant powdered pumpkin drink was developed as a value-added product based on the nutrient analysis data and the powder properties of flesh in different pumpkin varieties. Experimental results of the powder properties along with the nutritional composition have highlighted 'Rajah', which was an imported hybrid variety belongs to *C. maxima*, as the variety with the highest nutritional composition and beneficial powder properties important in developing a powdered drink. Variety 'Rajah' was reported with 28.86 g of proteins, 51.93 g of carbohydrates, 3.84 g of fat, 10.94 g of crude fibre, 147.10 mg AAE of antioxidant potential, 7.76 mg of Fe, 8841.43 mg of K, and 196.51 mg of Mg. In addition to that, dispersibility as 8.42 gcm^{-3}, solubility as 0.58 g^{-1}, loose bulk density as 0.43 gcm^{-3}, and wettability as 8.27 s were reported in variety 'Rajah'. Out of the five different instant drink types, the sensory evaluation finalized '325' with a significant overall acceptability, which was made by supplementing cinnamon extract and stevia in 1:1. Along with that, overall acceptability and the food action rating results of the sensory evaluation have highlighted the possibility of upgrading this product into a more consumer preferred product, which could be utilized as a nutritious value-added product to address the nutrient deficiencies and as an effective way of reducing post-harvest loss associated with pumpkin. To generalize the study findings about the nutrient composition variation between *C. maxima* and *C. moschata*, conducting further analysis are suggested using more pumpkin varieties collected from different locations belong to different agro-ecological regions in Sri Lanka since the study has focussed only on a specific area belongs to the DL1b region of the island. In addition to that, conducting studies that extends the utilization of powdered pumpkin in different value addition processes related to wide range of industrial applications, are suggested.

Conflict of Interest

The authors declare no conflict of interest.

Acknowledgement

Financial assistance from the Department of Botany of the University of Sri Jayewardenepura is acknowledged.

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