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Research Paper

Development of a pre-cooked supplementary food using Palmyrah tuber

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Abstract: Incorporation of legumes and tuber flours could improve the protein quality and energy content of traditional supplementary foods prepared mainly from cereals such as maize and sorghum in the developing countries. This study focused on developing a nutritious supplementary food using staple cereals, legumes and palmyrah tuber. "PalmyrahNutrimix" was formulated from the flour of cowpea, chickpea, sesame, green gram, soya bean and palmyrah tuber. Palmyrah tuber flour was obtained through tuber boiling, sun drying and milling process. Sugar and palmyrah tuber flour were optimized *via* 25 treatments. Sensory evaluation results revealed that three formulae consisting of sugar (19.4%) with different ratio of boiled and dried palmyrah tuber flour (15.9%, 18.2% and 20.3%) scored the highest mean rank sum (71.6), which complies with the Sri Lankan standards for energy (468.37 kcal/100g), protein (15.66%), fat (10.08%), fiber (4.75%) and carbohydrate (61.15%). The total phenolic content (61.0±2.0 mg gallic acid equivalent/100g) confirmed the positive functional properties of the product. Water activity of the product (0.46) assured the keeping quality of the supplementary food mix. Glycemic Index (GI) values of the product with sugar and without sugar were 64.00 ± 1.90 and 50.50 ± 1.26, respectively. Low GI value (50.50) showed that without sugar, product could be given to people with diabetes. The market survey conducted with 30 families indicated that they preferred "PalmyrahNutrimix", which scored for sensory attributes better than market available products. Shelf life of the product was at acceptable level in both HDPE (High Density Polyethylene) and MPS (Metalized Polystyrene) packaging materials for a period of six months. This study concludes that "PalmyrahNutrimix" meets Sri Lankan standards as a supplementary food with sufficient consumer acceptability and keeping quality.

Keywords: *Supplementary food, Palmyrah tuber flour, Protein quality, Glycemic Index*

Introduction

In many developing countries, traditional supplementary foods are prepared mainly from cereals such as rice (*Oryza sativa* L), maize (*Zea mays* L), millets and sorghum (*Sorghum bicolor* (L) Moench], which are usually poor in protein quantity and quality, and supply around 50% of energy (NHMRC, 2003). It is therefore, desirable to study the ways and means of developing more nutritious supplementary foods with a higher energy content and improved protein quality.

In Sri Lanka, "Triposha" is the most popular supplementary food product though only 40% of its ingredients are locally available and the rest is of imported ingredients (Jayatissa *et al*., 2012). "Samaposha" is also available in the Sri Lankan market, consisting of maize, soya bean [*Glycine max* (L) Merr], rice and green gram (*Vigna radiata* L). However, the main ingredients in both products is deficient in fat, fiber and other micronutrients such as phytochemicals (Jayatissa *et al*., 2012), which are available in the tuber flour of palmyrah (*Borassus flabellifer* L) and some locally available resources such as cowpea [*Vigna unguiculata* (L) Walp], chickpea (*Cicer arietinum* L) and sesame (*Sesamum indicum* L).

Palmyrah Development Board produces "Palmposha" made out of rice flour, black gram [*Vigna mungo* (L) Hepper] flour, green gram flour, soya bean flour, boiled palmyrah tuber flour and sugar using domestic processing techniques. However, the composition does not meet the expected nutrient provision for the consumers, standards as supplementary foods and keeping quality during storage. Hence, there is a high demand for a better formulation of a nutritious product using locally available resources.

The palmyrah tuber flour contains high amount of Na, K, Ca and Mg and the literature states that it contains other essential minerals and vitamins as well (Jansz *et al*., 2002; Krishanthy *et al*., 2008). In addition, the nutrient profile of palmyrah tuber compares favourably with other staples such as rice, wheat (*Triticum aestivum* L), maize and is a better source of nutrition than cassava (*Manihot esculenta* Crantz) and potato (*Solanum tuberosum* L) (Theivendirarajah, 2008). Cowpea provides lysine, which is deficient in cereals, while cereals supply methionine and cystine that are not found in legumes. Hence, a mixed diet of legumes and cereals can provide an adequate protein supply (Dovlo *et al*., 1976, Prinyawiwatkul *et al*., 2009). Chickpea and cowpea are the main sources of folate (https://ndb.nal.usda.gov/ndb/), green gram and palmyrah tuber are the best sources of fiber, soya bean is the best source of high quality protein while sesame is the best source of lipids (Unsaturated Fatty Acids), iron, calcium, niacin and thiamine (Onsaard *et al*., 2010). Foaming capacity and foam stability are significantly higher in chickpea and cowpea flours, respectively (Sreerama *et al*., 2012).

Considering the above facts this study was designed to develop a supplementary food "PalmyrahNutrimix", by incorporating locally available grains and pulses *i.e.* cowpea, chickpea, green gram, sesame, sugar and palmyrah tuber flour in order to improve both nutrition and quality of the final product.

Methodology

<u>Raw materials and chemicals</u>
Green gram (*Vigna radiata)*, chickpea (*Cicer arietinum)*, cowpea (*Vigna unguiculata L.*), sesame (*Sesamum indicum*), soya bean (*Glycine max*), sugar and whole milk powder were purchased from the local market in Jaffna, Sri Lanka. Materials for chemical analysis were supplied by the Palmyrah Research Institute, Kaithady, Jaffna, Sri Lanka.

<u>Preparation of boiled palmyrah tuber flour</u>
Palmyrah tubers were cleaned and boiled for 15 min at atmospheric pressure. The surface fibers of the tubers were removed by using knives and the tubers were cut into thin sections crosswise. The cut tubers were then ground using a hammer mill (Premir, India, 550 rpm) and sieved with 0.85 mm mesh screen. Finally, the tuber flour was packed in high-density polyethylene (HDPE) bags and stored at room temperature (~32 °C).

<u>Preparation of soya bean flour</u>
The yellowish green varieties of soya bean, which is free from immature, field damaged and black soya beans were selected and screened to remove foreign material. It was washed with running water to separate broken and cracked soya beans and weed seeds. Roasting was done at 130 °C on flame without burning for 7.5 min and allowed to cool. Roasted soya beans were ground in hammer mill (Premir, India, 550 rpm), sieved with 0.85 mm mesh screen and the soya flour obtained was

packed in high density polyethylene (HDPE) bags and stored at room temperature (~32 °C).

Preparation of cowpea and green gram flour

The same procedure applied for sorting, cleaning and roasting of soya beans was followed for sorting of cowpea and green gram. It was then de-hulled in a hand-operated grindstone for removal of husk. Husk was removed by hand winnowing. Roasted cowpea and green gram were ground and sieved with 0.85 mm mesh screen. Cowpea and green gram flour was packed in HDPE bags and stored at room temperature (~32 °C).

Preparation of chickpea flour

The same procedure applied for sorting and cleaning of soya beans was followed for sorting of chickpea. It was roasted 130 °C on flame, without burning, for 10 min. Roasted chickpeas were ground and sieved with 0.85 mm mesh screen. Finally, chickpea flour was packed in HDPE bags and stored at room temperature (~32 °C).

Preparation of sesame flour

The sesame seeds were cleaned and sorted by soaking in water and removing the seeds that floated on top. The good seeds were collected. Then the ruptured seed coats were separated by scrubbing between the palms and air dried to get rid of excess water. Roasting was done thereafter at 130 °C on flame, without burning, for 7.5 min and allowed to cool. Roasted sesame seeds were ground in an electric grinder (Philips HL 1643, India, 550 rpm) to a fine powder. Flours obtained were stored in airtight container until use.

Formulation of precooked supplementary food

Different proportions of formulae were prepared and packed in HDPE bags, sealed and stored at room temperature (Figure 1). Different portions of boiled palmyrah tuber flour (32.5, 40, 47.5, 55, 62.5 g) and five different percentage of sugars (12.5, 15, 17.5, 20, 22.5) were initially mixed with 40 g of cowpea, 40 g of chickpea, 25 g of sesame, 25 g of green gram and 25 g of soya bean flour to select the best sugar percentage for different portions of tuber flour (25 treatments). The 2nd sensory evaluation test was then conducted to identify the best palmyrah tuber flour amount and sugar percentage (X% identified from 1st sensory test) for the "PalmyrahNutrimix". Sensory evaluation was conducted for the product prepared as "*Aggala*" out of the treatment mixtures.

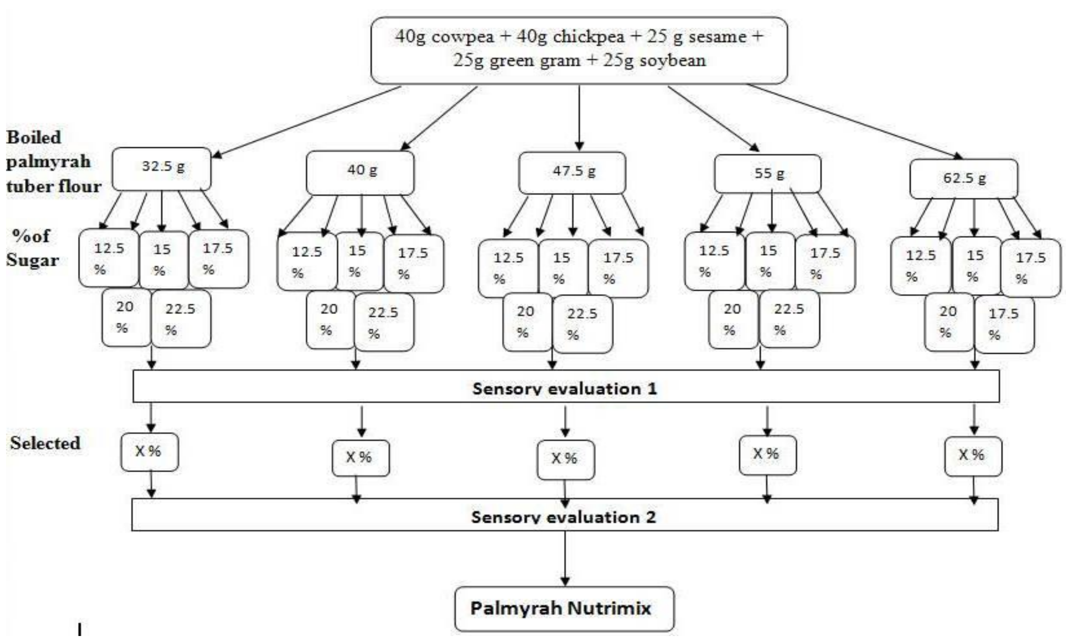

Figure 1. Treatment process and selection of final formula for "PalmyrahNutrimix"

Proximate composition analysis

Triplicate tests were carried out for moisture content, total ash, acid insoluble ash, crude fat, crude protein and crude fiber as per AOAC Official Methods (AOAC, 2007). Carbohydrate content (CC) was estimated by the difference of other components using the formula:

CC = 100% - (% moisture + % protein + % fat + % ash)

Total phenolic content

A 1.5 ml aliquot of Folin-Ciocalteu's reagent (10 times diluted) was added to test tubes containing 0.3 ml of standards or sample extract, and the contents were mixed thoroughly by vortex. The reaction mixture was neutralized by adding 1.2 ml of sodium carbonate (7.5 % w/v) to each tube and vortexed well. Tubes were allowed to stand at room temperature in the dark for 35 min. The absorbance was measured at 765 nm by spectrophotometer (UV-2602, Labomed Inc, USA), using aqueous 80% (v/v) methanol as blank. The content of total phenolics in each extract was determined using a standard curve prepared for gallic acid and expressed as milligrams of gallic acid equivalents (GAE) per gram of food sample.

Sensory evaluation

Pre-cooked supplementary foods were tested by a panel of 23 untrained panellists. The panellists were selected from preschool-aged children, school-aged children, adolescents, adults and elders. The judges were briefed about the procedure for judgment and making the product within the numerical value of 1-5 in ascending order of quality parameters such as taste, color, flavor, odor and overall acceptability.

Statistical analysis

The data recorded on various parameters were statistically analyzed using Friedman test, Kiruskal-Walllis test and Wilcoxon signed rank test using MINITAB 15 software. Means (N=3) were separated by Least Significant Difference (LSD) test at p=0.05.

Results and Discussion

Sensory evaluation of pre-cooked supplementary food

The rank sums of different sensory parameters are given in Table 1. There was no statistically significant variation (p>0.05) among different formulas with regard to sensory attributes. However, the results shown indicated that in terms of texture and overall acceptability, the highest score was observed in S_3, followed by S_2 and S_4. According to the highest rank sum, it is suggested that the samples S_2, S_3 and S_4 have better quality than the other samples prepared.

Table 1. Probability values and rank sums obtained by S_1, S_2, S_3, S_4 and S_5 formulae for sensory attributes

Samples*	Taste	Flavour	Colour	Sensory parameters	
				Texture	Overall acceptability
S_1	71.5^a	74.5^a	72.0^a	66.5^d	63.0^d
S_2	65.9^a	66.0^a	67.5^a	71.0^b	70.5^b
S_3	77.0a	73.5^a	72.5^a	77.0^a	76.5^a
S_4	69.0^a	69.0^a	69.5^a	67.0^c	68.5^c
S_5	62.9^a	62.5^a	63.5^a	63.5^d	57.0^d

Data expressed in Rank sum; within a column, means followed by the same letter are not significantly different by the LSD at p=0.05; *[(Formula: 40g cowpea + 40g chickpea + 25 g sesame + 25g green gram + 25 g soya bean + boiled tuber flour and different percentage of total weight of sugars); (S_1 = 32.5 g boiled tuber flour +12.5% total weight of sugar; S_2 = 40 g boiled tuber flour + 15% total weight of sugar; S_3 = 47.5 g boiled tuber flour + 17.5% total weight of sugar; S_4 = 55 g boiled tuber flour + 20 % total weight of sugar; S_5 = 62.5 g boiled tuber flour + 22.5% total weight of sugar)].

Proximate composition of supplementary food

All constituents showed no significant (p>0.05) difference among the three samples (S_2, S_3, and S_4; Table 2). Therefore, a formula could not be selected based on the nutrient content, as each formula differed only by the amount of boiled palmyrah tuber flour added to the mixture. Hence, the formula containing the highest content (55 g) of palmyrah tuber flour was selected (S_4) for "PalmyrahNutrimix" (PNM).

The moisture contents of the prepared samples are also shown in Table 2. The lowest moisture content was found in S_3 and the highest in S_4. The highest ash content was found in S_2 followed by S_3 and S_4, respectively. The protein content in S_3 was higher than that of S_3 and S_4. The fat content in S_2 was higher than that of the S_3 and S_4.

Nutritional importance of "PalyrahNutrimix" The proximate composition of the final formula indicated that energy, fat and fibre provided by PNM is higher than the commercial product. However, protein and carbohydrate contents were lower in the PNM formula compared to those of the commercial product. Total phenolic content of developed supplementary food PNM was 0.61 ± 0.20 (mg Gallic acid equivalents/ g). The water activity of developed supplementary food confirmed that product might have longer shelf life at the temperature of 31 °C.

Table 2. Proximate compositions of different formulae of developed "PalmyrahNutrimix"

Components (% dry weight basis)	**Formula***			
	S2	**S3**	**S4**	**P value**
Moisture	5.89±0.11	5.47±0.21	5.95±0.12	0.066
Ash	2,48±0.05	2.36±0.03	2.41±0.03	0.057
Acid insoluble ash	0.06±0,10	0.07±0.03	0.09±0.03	0.214
Protein	15.82±0.14	15.70±0.25	15.66±0.09	0.337
Fat	10.40±0.07	10.06±0.82	10.08±0.11	0.301
Fiber	4.24±0.13	4.54±0.17	4.75±0.23	0.063
Total carbohydrate (by difference)	61.07±0.18	61.86±0.97	61.15±0.22	0.739

*[(Formula: 40 g cowpea + 40 g chickpea + 25 g sesame + 25 g green gram + 25 g soya bean + boiled tuber flour and different percentage of total weight of sugars); (S_2 = 40 g boiled tuber flour + 15% total weight of sugar; S_3 = 47.5 g boiled tuber flour + 17.5% total weight of sugar; S_4 = 55 g boiled tuber flour + 20 % total weight of sugar)].

Glycemic Index

The PNM and the "Diabetic PalmyrahNutrimix" (D.PNM) were tested for Glycemic Index (GI) using 10 volunteers (5 men, 5 women). The Mean Blood Glucose Curves of Standard food (pure glucose), PNM and D.PNM are illustrated in Figure 2. Results indicated that the PNM has a moderate GI value 64.00±1.9 and the D.PNM has a low GI value (50.50±1.26) according to the scale of Miller *et al.* (2002).

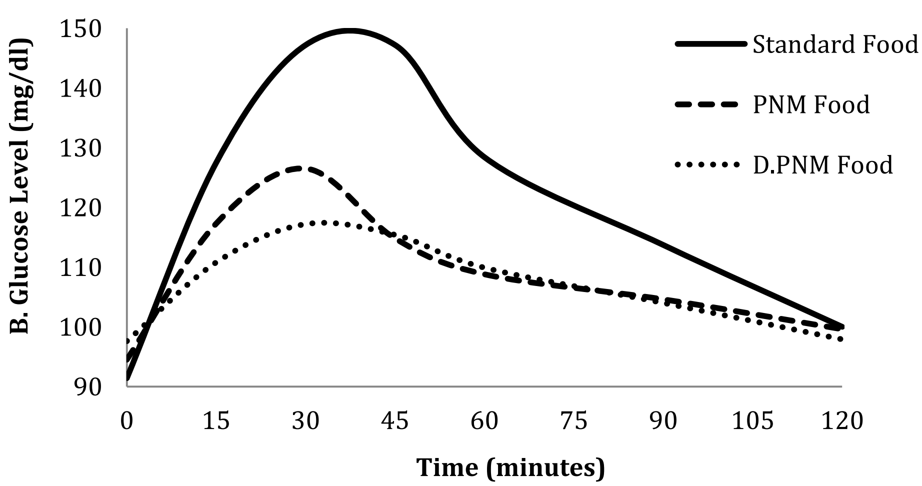

Figure 2. Mean Blood Glucose Curves of Standard food (pure glucose), "PalmyrahNutrimix" (PNM) and "Diabetic PalmyrahNutrimix" (D.PNM).

Sensory attributes

The PNM obtained the highest median scores on all sensory attributes when compared to the Palmposha product (Figure 3). Figure 4 illustrates that all sensory attributes of PNM were liked extremely by he subjects compared to those of "Palmposha", which was moderately liked by most of the subjects. Few people (<10%) liked "Palmposha" more than the PNM.

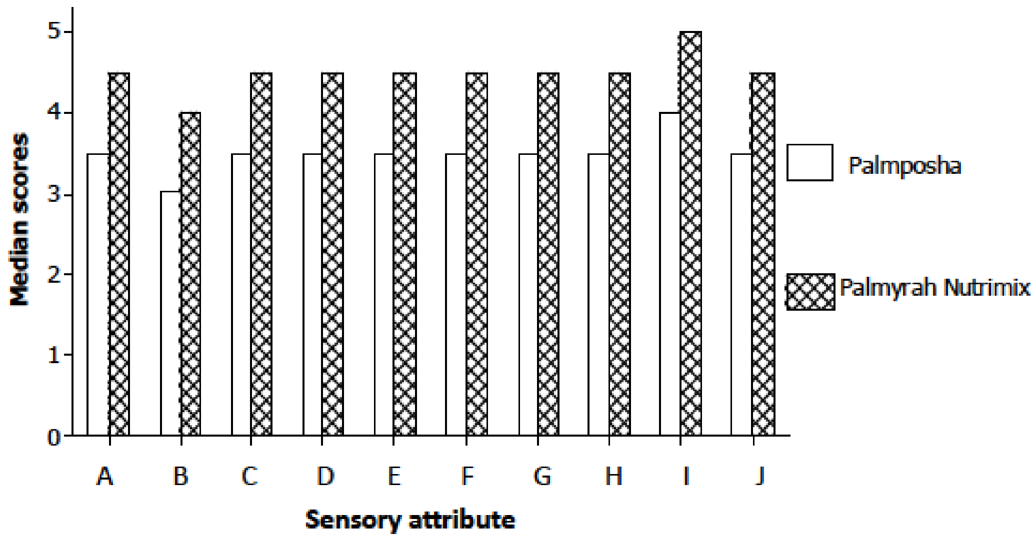

Figure 3. Median scores for the sensory attributes of "Palmposh" and "PalmyrahNutrimix"; N = 125 (attributes checked were; A = Taste, B = Taste after consumption, C = Mouth feel, D = Appearance, E = Flavor, F = Chewiness, G = Texture, H = Quality after added water, I = Quality after added scraped coconut, J = Overall acceptability)

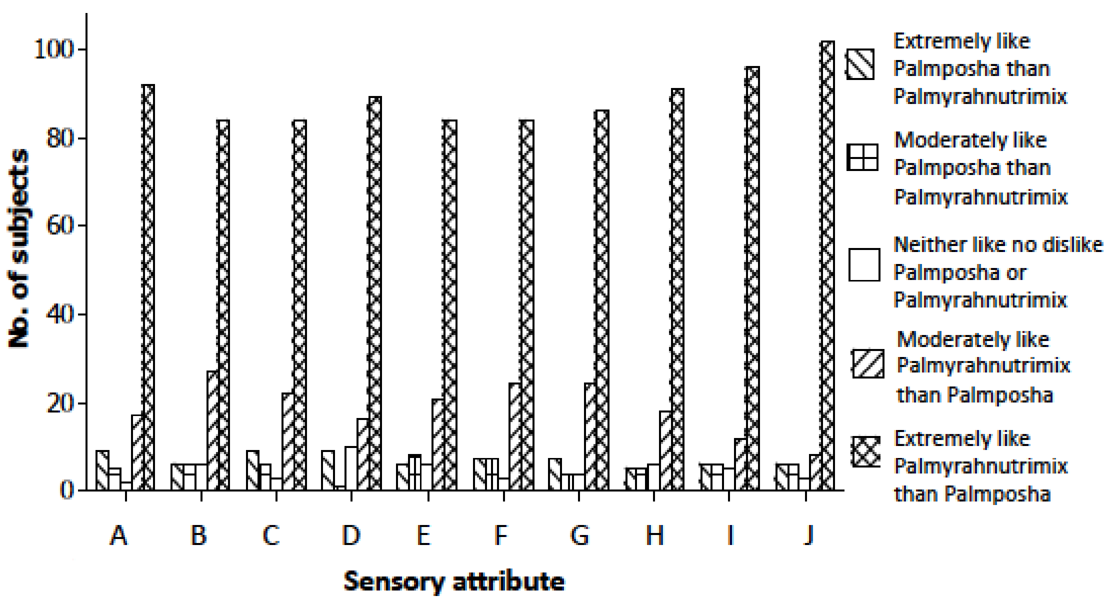

Figure 4. Number of preference for the sensory attributes for "Palmposha" and "PalmyrahNutrimix" (attributes checked were; A = Taste, B = Taste after consumption, C = Mouth feel, D = Appearance, E = Flavor, F = Chewiness, G = Texture, H = Quality after added water, I = Quality after added scraped coconut, J = Overall acceptability)

Keeping quality

Keeping quality of "PalmyrahNutrimix" (PNM) was evaluated by determining the changes of peroxide value (PV) and water activity (a_w). Initially, the peroxide value of the PNM was 0.87 mEq/kg. After storage in HDPE package, the peroxide values were measured in 2nd, 4th and 6th month as 1.80, 1.88, 2.01 mEq/kg, respectively, while the samples stored in MPS measured in the same intervals were recorded as 1.00, 1.04 and 1.19 mEq/kg at room temperature, respectively. The low peroxide values indicated that the product was stable against oxidation after 6-months storage period, even though the product contained 9.2% of sesame that provides considerably high amount of fat to the product.

At the beginning, the water activity of the PNM was 0.462±0.002. The HDPE storage changed the water activity as 0.492, 0.532 and 0.579 when measured at two-month intervals, while the corresponding values at MPS storage were 0.483, 0.520 and 0.547, respectively. Thus, MPS is more effective than HDPE as a packaging material for PNM. Samples of PNM showed negative results for the total plate count, yeast and moulds. The results are in agreement with the Sri Lanka Standards set by the Sri Lanka Standards Institution (SLSI, 2011; SLS 1036: 2011) for processed cereal-based foods. Coliforms test also showed that the product complies with the Sri Lankan Standard (maximum allowable range $1 \times 10^1 – 1 \times 10^2$ in food).

Conclusion

A supplementary food PalmyrahNutrimix was successfully developed with acceptable sensory qualities by incorporating locally available ingredients, namely, 14.8% cowpea, 14.8% chickpea, 9.2% sesame, 9.2% soybean, 9.2% green gram, 20.3% palmyrah tuber flour, 19.4% sugar and 3% whole milk powder. The preparation process was relatively simple. The "PalmyrahNutrimix" was the most accepted product among the tested products, in sensory evaluation by all subjects above two years of age. The developed supplementary food meets the Sri Lanka Standards (SLS) recommendations for energy, protein, fat, fiber and sodium content. Further, "PalmyrahNutrimix" has a medium Glycemic Index (GI) and "Diabetic PalmyrahNutrimix" had a low GI value. Metalized Polystyrene (MPS) packaging material is more effective than High Density Polyethylene (HDPE) for storage of PalmyrahNutrimix.

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