Original Research Article

Formulation, sensory evaluation and nutrient assessment of extruded composite flour mixtures developed using selected local grains varieties

Abstract

This study is focused on formulating a composite flour, rich in essential nutrients using selected grain varieties available in Sri Lanka. The traditional rice variety, *Kalu heenati* was used as the major ingredient in developing the extruded products. Rice flour (RF), Mung bean flour (MF), Black gram flour (BF), and Meneri flour (MF) together with cinnamon powder, sesame and black seeds were composited in developing the formulations based on the nutrient compositions. Thus, 16 composite flour mixtures were formulated fitting to the two-factor factorial experimental design and those formulations were extruded. Grounded samples were served with 1.5% sugar to a consumer-based sensory panel (n=35) to select the best extruded samples organoleptically. Sensorially, the best 4 samples were subjected to proximate analysis according to the AOAC protocols. Results revealed that the $F_{3.4}$ formulation was sensorially acceptable as per the descriptive analysis. Proximate analysis of best extruded formulation had carbohydrates, protein, fat, dietary fiber, and ash respectively as 63.37±0.02%, 20.91±0.03%, 6.01±0.06%, 9.20±0.01%, and 2.41±0.02%. Mineral analysis showed that it contained calcium, sodium, iron and zinc in mg/100g as 840.70± 0.01, 413.06± 0.01, 6.73± 0.01, and 3.22± 0.04 respectively. This formulation can be promoted as a value-added product to address nutritional requirement of Sri Lankans.

Keywords: *Kalu heenati*, *Panicum miliaceum*, Black gram, Green gram, Composite flour mixtures,

Introduction

Modern consumeristic dietary patterns and artificial food stuffs have been identified as a major issue for the increasing risks of Non-Communicable Diseases (NCDs). Therefore, people are inclined to consume convenient and nutritious food products while adopting healthy dietary patterns. Grains are most widely consumed by people all over the world for a long time; most often, for their breakfast as a significant portion of protein and other essential nutrients are derived from grains. Further, the fiber-rich seed coat of legumes and cereals make them high in dietary fiber. There are numerous types of traditional rice and other grains varieties available in Sri Lanka. In the case of traditional rice cultivars which are regarded as having important health benefits such as low glycemic index, high antioxidant activity and high fiber content. (Abeysekera et al., 2017a; 2017b; Samaranayake et al., 2017). Also as being the staple food in most of the Asian countries, rice significantly contribute to fulfill the energy, fat and protein requirements of consumers. In order to create nutrient enriched products, rice is preferred to be utilized in composite flour technology as a major raw material along with other grains.

Further, the selected grains can be used to formulate nutrient enriched novel products with an improved nutritional profile because, composite flour technology is beneficial to promote the use of locally cultivated grains (Hugo et al., 2000; Mamat et al., 2014). Nevertheless, several countries have initiated programs to explore the possibility of using composite flours as alternatives to wheat flour using locally available grain varieties. (Abdelghafor et al., 2011).

Nowadays, a lot of convenient food products with specific qualities are produced using extrusion technology. Extrusion cooking is a technological procedure that entails a number of technical operations carried out under high, temperature, pressure and shear force (Herath et al, 2018). Products with distinctive textural traits can be produced utilizing this method. Many of ready to eat breakfast cereals and grains are extruded products that are typically consumed with milk in consumeristic society today. One significant benefit of the extrusion method is the capability to produce a variety of finished food products effectively from low-cost basic materials (Berrios et al, 2013).

Hence, aim of this study is to produce an extruded product out of composite flour technology and to evaluate the physiochemical properties of developed product using selected grain varieties available in Sri Lanka, namely; *Kalu heentai*, *Panicum miliaceum* (locally known as Meneri), green gram, black gram, black sesame, black seeds. Kaluheenati (red rice variety) was used as the major ingredient in this study. As stated in literature, the consumption of rice has been increased with introduction of diversified rice based products to the market (Perera et al., 2022). Also, traditional rice possesses high amount of easily digestible carbohydrates and the consumption of rice based products is preferred by coeliac patients who are intolerant to gluten protein in wheat flour (Sivaramakrishnan et al., 2004). Black gram and green gram are considered as rich sources of protein (Mekkar et al., 2021) whereas meneri is reported to have high leucine, isoleucine, and methionine content (Saleh et al., 2013). Black seeds and sesame seeds used as minor ingredients are rich sources of oil and minerals (Wang et al., 2018; Tavakkoli et al., 2017). Cinnamon was also used as a minor ingredient to give a unique fragrance to the final formulae. As reported in literature, cinnamon possess the unique fragrance and various bio-active compounds due to the presence cinnamaldehyde and *trans*- cinnamaldehyde in it (yeh et al, 2013) along with the functional, antioxidant and antimicrobial properties.

Materials and methods

Comprehensive literature survey was carried out based on traditional knowledge of grains and estimated nutrient compositions in order to select raw ingredients to develop the composite flour formulations. Accordingly, most suitable major and minor ingredients were selected while traditional rice as the basic major raw material.

Raw Materials: Red rice *'Kalu Heenati'* (WF 13272**)** was purchased from "Gurusingha organic food outlet", Homagama. Green gram MI 06 variety, Black gram MI 01 and *Panicum miliaceum* I.P.M. 2705 variety were obtained from Fields Crops Development and Research Institute, Mahailuppallma. Decorticated Black sesame, Black seeds and cinnamon were purchased from local market at Colombo.

All grains varieties, namely red rice, green gram, black gram, *meneri*, black sesame, black seed were screened for stones, rots and other foreign materials and thoroughly washed and cleaned with water for several times prior to use.

Preparation of powdered samples: Green Gram and Black Gram seeds were soaked in cold water for 6 hours at $28 \pm 2^{\circ}C$ and *meneri* was also soaked in cold water at $28 \pm 2^{\circ}C$ for 3 hours. Thereafter, those samples were dried in a cabinet dryer (Xingtai-China, model: XTDQ-101-5A) at $60 \pm 5^{\circ}C$ for 6 hours, ground using a grinder (Bio-base©, HSD-80, China) to get fine particles and passed through a 180 μm sieve. The ground flour samples were packed in sealed polythene bags and stored in a refrigerator for the subsequent use of the study. Red rice samples were subjected to oven drying at $60 \pm 5^{\circ}C$ for 6 hours, ground using a grinder (Bio-base©, HSD-80, China) to get fine powder and passed through a 180 μm sieve after removing impurities. Sesame seeds and Black seeds were blanched, dried and used as whole grains without powdering. Cinnamon sticks were also washed thoroughly with water to remove rots, & foreign materials, were dried at $60 \pm 5^{\circ}C$ for 6 hours to get fine particles using a grinder (Bio-base©, HSD-80, China).

Preparation of composite flour formulations: Composite flour formulations were prepared by mixing the powdered ingredients in ratios according to the two-factor factorial experimental design. High and low levels for each ingredient were decided based on estimated nutrient compositions. These two levels of ingredients in grams; for rice, 40(A_0), 50 (A_1), for green gram 20 (B_0), 30 (B_1), for black gram 10 (C_0), 15(C_1) and for meneri 25(D_0), 35(D_1). Flour was mixed with pure water (50 ml/100 g) at room temperature ($28^{\circ}C$) to obtain a dough at suitable consistency. Thereafter, the dough was extruded using a single screw extruder at 95℃ − 100℃ (Guha and Ali, 2006) to get fully gelatinized product. The extruded flour formulations were dried in a cabinet dryer at 60 ± 5℃ for 6 hours to get the safe moisture content. The dried extruded samples were ground to get fine powder using laboratory scale grinder (Bio-base©, HSD-80, China). Finally black sesame seeds, black seeds and cinnamon were added to the powdered mixtures in 5, 1 and 0.1 grams respectively.

Sensory evaluation: All 16 composite flour formulations (extruded ground products) pertain to the two factor-factorial design were grouped into 4 clusters (Table 1) considering the four variables. Therein, the sensorially best treatment of each cluster was selected in terms of the sensory stimulus "overall acceptability" using five point hedonic scale. In cluster 1 where 4 formulations generating from first two variables (A and B) were subjected to sensory evaluation in order to select the best treatment combination. Thereafter, formulations generate from variable C with the combination of variables A and B (first cluster) illustrated in cluster 2 were subjected to sensory evaluation in selecting the best treatment combination organoleptically. Finally, formulations forming from variable C, combining with the variables in cluster 1 as well as cluster 2, depicted in cluster 3 and 4 respectively were subjected to sensory evaluation with a view to select the best treatment combination from each cluster (cluster 3 and 4). Lastly, four (4) best formulations selected from each cluster were again sensorially tested to select very best treatment combination according to the acceptance test using six sensory stimuli namely appearance, smell, texture, flavor, mouth feel and overall acceptability using the same five-point hedonic scale.

Table 1: Sixteen (16) composite flour formulations subjected to the sensory evaluation

Cluster	Trial number	Abbreviation	Treatment combination
1	1	$F_{1.1}$	$A_0B_0C_0D_0$ (1)
	2	$F_{1.2}$	$A_1B_0C_0D_0$ (a)
	3	$F_{1.3}$	$A_0B_1C_0D_0$ (b)
	4	$F_{1.4}$	$A_1B_1C_0D_0$ (ab)
2	1	$F_{2.1}$	$A_0B_0C_1D_0$ (c)
	2	$F_{2.2}$	$A_1B_0C_1D_0$ (ac)
	3	$F_{2.3}$	$A_0B_1C_1D_0$ (bc)
	4	$F_{2.4}$	$A_1B_1C_1D_0$ (abc)
3	1	$F_{3.1}$	$A_0B_0C_0D_1$ (d)
	2	$F_{3.2}$	$A_1B_0C_0D_1$ (ad)
	3	$F_{3.3}$	$A_0B_1C_0D_1$ (bd)
	4	$F_{3.4}$	$A_1B_1C_0D_1$ (abd)
4	1	$F_{4.1}$	$A_0B_0C_1D_1$ (cd)
	2	$F_{4.2}$	$A_1B_0C_1D_1$ (acd)
	3	$F_{4.3}$	$A_0B_1C_1D_1$ (bcd)
	4	$F_{4.4}$	$A_1B_1C_1D_1$ (abcd)

Numerical letter 0 depicts lower level and letter 1 depicts high level of variables in terms of weights of ingredients; where A= Rice, B= Green gram, C= Black gram and D= *Meneri*

The sensory evaluation was performed by employing 35 number of consumer-based panelist. Ethical approval for the study was obtained from Ethics Review Committee, Humanities and Social Sciences, University of Sri Jayewardenepura, Sri Lanka. Before beginning the sensory evaluation, the respondents were briefly elaborated for their task and their consent were also taken. Thereafter, they were asked to indicate their magnitude of perception pertain to the given sensory attribute/s using numerical numbers of the hedonic scale, where 1 =dislike strongly, 2= dislike somewhat, 3= neither like nor dislike, 4=like somewhat, 5= like strongly. Data obtained from the sensory evaluation were analyzed by resorting Friedman statistical test method. Afterward, the best formulations were further subjected to proximate analysis. Further, the sensory evaluation for 16 flour formulations was repeated five times using reproducible samples as well as employing same sensory panel.

Samples preparation for sensory evaluation: The extruded dry composite flour formulations obtained from 16 treatment combinations were mixed with 1.50% sucrose (white cane sugar). Then 25g of each sample was presented to a panelist to gauge the perception towards the sensory stimulus overall acceptability. Same procedure was followed for the second sensory evaluation. However, it had 6 sensory stimuli, namely; appearance, smell, texture, flavor, mouth feel, overall acceptability.

Chemicals: All the chemicals used for proximate analysis were analytical grade. Ethanol used for dietary fiber analysis was commercial grade purchased from Sigma-Aldrich Chemie GmbH, Steinheim, Germany.

Proximate analysis: Proximate analysis of composite flour formulations was done in triplicates following the AOAC official methods 2012. Moisture content of flour samples were determined according to AOAC official method 2012 92509B. Crude protein content was determined according to the Kjeldahl method as described in AOAC official method 2012 920.87 using heating digester (VELP SCIENTIFICA-DKL 8, Italy) and automated distillation unit (VELP SCIENTIFICA-UDK49, Europe). Crude fat content was determined by Soxhlet fat extraction method using petroleum ether followed by AOAC, 2012 920.39C. Crude fiber content was determined as described in AOAC, 2012 962.09E using Fibertec™ M6 Fibre Analysis System (FOSS-1020 HOT EXTRACTOR). Ash content was determined as specified in AOAC 2012 923.0311 by dry ashing method with gravimetric principal. Total carbohydrate content was determined according to the AOAC Method 44.1.30 - phenol sulphuric method.

Quantification of mineral content in composite flour formulations: Samples were digested according to the method described by Jones and Janick, 1984. Nitric and perchloric was added to 1 g of the sample in the ratio of 9:4. It was heated on a hot plate until the emission of brown fumes ceases. It was then cooled and diluted up to the mark by de ionized water. Solutions of 100 mg/L were prepared from each stock solution to analyze the selected elements.

Calcium (Ca), sodium (Na), iron (Fe) and zinc (Zn) were determined using Atomic Absorption Spectrophotometer (AAS Model SP9). All values were expressed in mg/100g. All treatments were replicated thrice and results obtained from this study were compared with a leading brand available in the market.

Statistical analysis

The sensory profiles were prepared using the mean score values obtained for each sensory attribute in the second sensory evaluation. Differences in sensory attributes of the composite flour formulations were compared using the Friedman non-parametric test, carried out using SPSS 23 for windows software. The proximate analysis of the formulations were compared according to one way ANOVA followed by Tukey sample comparison using Minitab 17 software.

Results and Discussion

In this study, selected grain varieties were used in formulation of composite flour mixtures according to two factor factorial design. As reported in literature whole grains are abundant in dietary fiber and components with high functional properties (Dhingra et al, 2012). In order to re-asses those findings, proximate composition of selected grains used for this study were analyzed and results are given in table 2.

Table 2: Nutrient composition of raw ingredients

Ingredient	Ash %	Fat %	Protein%	Dietary fiber %	Carbohydrate %
Red rice	1.88± 0.12	2.41± 0.02	11.91± 0.01	4.99± 0.01	77.85± 0.23
Black Gram	3.48± 0.01	1.00± 0.02	29.02± 0.03	12.15± 0.13	57.02± 0.07
Green Gram	3.37± 0.02	1.02± 0.04	28.10± 0.01	11.73± 0.02	56.71± 0.02
Meneri	2.55± 0.03	1.82± 0.12	10.95± 0.12	10.91± 0.01	73.62± 0.02
Black seed	8.93± 0.01	43.09± 0.02	20.72± 0.01	6.54± 0.02	19.91± 0.10
Black sesame	3.92± 0.04	48.46± 0.18	16.09± 0.01	12.01± 0.40	20.12± 0.09

Note: Data presented as Mean± Standard Deviation (n=3). Results of the proximate composition analysis are presented on a dry weight basis.

Different literatures have shown the importance and health benefits of this traditional rice variety. Kariyawasam et al. (2016b) have reported that *Kalu heenati* rice variety possess the highest protein content (11.00%) among six studied traditional rice varieties whereas this study reported a crude protein content of 11.91% for kaluheentai. However, Kaluheentai rice retained the highest carbohydrate content (77.85%) compared to the other raw materials used for this study. The crude fat content reported for kaluheenati was 2.41% which was higher than the reported values for black gram, green gram and meneri. Similar results were found by Kulasinghe et al., 2017, where crude fat content of kaluheentai was reported as 2.43%. In the case of black gram which has categorized as a high protein food source by the cereal-based society, this study also reported a highest percentage of protein (29.02%) comparative to the other ingredients used for this study. Studies conducted by the Department of Agriculture – Sri Lanka (DoA) 2015, was also brought to the notice, that black grams contained high percentage of proteins, vitamins and minerals. Nevertheless, black gram has recorded the highest crude fiber content (12.15%) than other variables utilized for this study. To impart a better visual perception to the composite flour mixtures, decorticated black gram-seeds were used. Green gram has also been identified as a good source of protein and according to this study it contained more than

25% protein. This finding was also corresponding to the findings of El-Adawy, 1996; Fan & Sosulski, 1974. They also reported, that green gram contained more than 25% protein. Lorenz, 1980 found out that sprouting during malting of green gram causes to increase protein and fiber contents considerably. The same findings have been reported by Murugkar et al, 2015, according to their study. In case of *meneri* which contained around 10.91% of dietary fiber and this amount was higher than that of red rice and black seeds. Nevertheless, Okwudili et al., 2017 reported that *meneri* was a rich source of bioactive compounds and other functional properties as well. Black seeds can be identified as a food source of high amount of minerals (8.93%) compared to other ingredients used in this study. Also, black seeds (20.72%) and black sesame seeds (16.09%) contained high amounts of protein compared to the protein contents of *kaluheenati* rice and *meneri*. Carbohydrate content of these two types of seed varieties is low compared to the major variables used in this study. However, these two were the major sources in providing a high fat content to the formulations against other variables. Black seeds contain around 43.09% oil whereas black sesame seeds contain 48.46% oil. However, presenting a high of oil content effects the shelf life of the final product. Therefore, to extend the shelf life of the final product, sesame seeds and Black seeds were used as whole grains without powdering.

Selecting best composite flour formulations of each cluster sensorially: Sixteen (16) Composite flour mixtures were formulated according to the two-factor factorial experimental design while using two levels for major ingredients and a constant level for other minor ingredients. The level of each ingredient was selected by referring the literature and previous studies.

First sensory evaluation: All 16 composite flour formulations in 4 clusters (Table 1) were subjected to sensory evaluation in order to select the best formulations of each cluster in terms of the sensory stimulus overall acceptability (overall mean rank) and results are illustrated in table 3.

Table 3: Overall mean ranks of 16 composite flour formulations for overall acceptability

Treatment combination	Overall acceptability	P value
$F_{1.1}$	**4.50±0.30**	0.000
$F_{1.2}$	2.45±0.72	
$F_{1.3}$	2.98±0.59	
$F_{1.4}$	3.04±0.43	
$F_{2.1}$	**4.55±0.69**	0.000
$F_{2.2}$	3.42±0.45	
$F_{2.3}$	2.22±0.62	
$F_{2.4}$	2.82±0.39	
$F_{3.1}$	3.03±0.50	0.000
$F_{3.2}$	3.90±0.78	
$F_{3.3}$	2.77±0.68	
$F_{3.4}$	**4.30±0.61**	
$F_{4.1}$	2.45±0.72	0.000
$F_{4.2}$	2.88±0.66	

$F_{4.3}$	**4.05±0.52**
$\mathbf{F_{4.4}}$	3.62±0.59

According to the results of Friedman test, the overall acceptability of four composite flour formulations of each cluster was significantly different ($p\leq 0.05$) at 5% significance level. Considering the cluster 1, formulation $F_{1.1}$ exhibits the highest mean rank value. Hence it was the highest preferred sample. In cluster 2, the formulation $F_{2.1}$ reported a highest mean rank value (4.55). When considering the cluster 3, formulation $F_{3.4}$ recorded the highest score comparatively other formulations. Finally, the formulation $F_{4.3}$ in the cluster 4 reported the highest mean rank value. By considering all those findings, the best formulation with respect to each cluster along with the flour ratios of the major raw materials are given in table 4.

Table 4: Sensorially selected best formulations of each cluster

Cluster	Denote by	Ratios (Grams) in composite flour mixture (RF: GF: BF: MF)
1	$F_{1.1}$	40:20:10:25
2	$F_{2.1}$	40:20:15:25
3	$F_{3.4}$	50:30:10:35
4	$F_{4.3}$	40:30:15:35

Note: The weight of ingredients is presented as ratios, RF: GF: BF: MF where RF=Rice Flour, GF=Green gram Flour, BF=Black gram Flour, MF= *Meneri* Flour

Selecting the best formulations out of four (4) composite flour samples

Second sensory evaluation: The best four composite flour formulations ($F_{1.1}$, $F_{2.1}$, $F_{3.4}$ and $F_{4.3}$) from four clusters were further subjected to sensory evaluation for six sensory stimuli and data obtained from it were analyzed in accordance with Friedman statistical test method. Outcome of the analysis showed that the P value for all the attributes except appearance was 0.000. The P value for appearance was 0.928. Accordingly, there is no significant difference ($p>0.05$) between 4 flour samples for appearance. However, there is a significant difference ($p<0.05$) between for smell, texture, flavour, mouth feel and overall acceptability of all four (4) flour samples. Hence, in order to further elaborate this outcome, the data obtained from second sensory evaluation (for 6 sensory stimuli) for the best four (4) flour formulations (obtained from 1st sensory evaluation) were used to calculate mean ($\bar{x}$) and standard deviation (sd) and results are depicting in table 5 as $\bar{x}$ ±sd.

Sensory characteristics	$F_{1.1}$	$F_{2.1}$	$F_{3.4}$	$F_{4.3}$
1. Appearance	4.37±0.62	4.30±0.60	4.33±0.48	4.27±0.73
2. Smell	3.80±0.61	3.03±0.72	3.83±0.74	3.83±0.55
3. Texture	4.27±0.52	2.80±0.71	4.33±0.55	3.83±0.75
4. Flavour	3.57±0.50	2.77±0.57	4.13±0.68	3.27±0.79
5. Mouth feel	3.57±0.73	2.87±0.68	4.23±0.63	3.37±0.49
6. Overall	4.00±0.64	2.23±0.86	4.37±0.56	3.20±0.48

acceptability

Table 5: Mean ($\bar{x}$) ±SD for sensory attributes for 4 composite flour formulations

According to the data given in table 5, the highest mean value for each sensory attribute is given by the formulation $F_{3.4}$ except the sensory stimulus appearance which was higher in $F_{1.1}$. However, it was not significantly difference ($p>0.05$) to the other formulations (Table 5). Hence, the formulation $F_{3.4}$ was selected as the best treatment as most of respondents prefer to it. While the next best formulation was $F_{1.1}$, the least preference given to $F_{2.1}$. To further elaborate the outcome given by the second sensory evaluation, sensory profiles pertaining to the best 4 formulations ($F_{1.1}$, $F_{2.1}$, $F_{3.4}$ & $F_{4.3}$) were drawn for six sensory attributes which are given in figure 1.

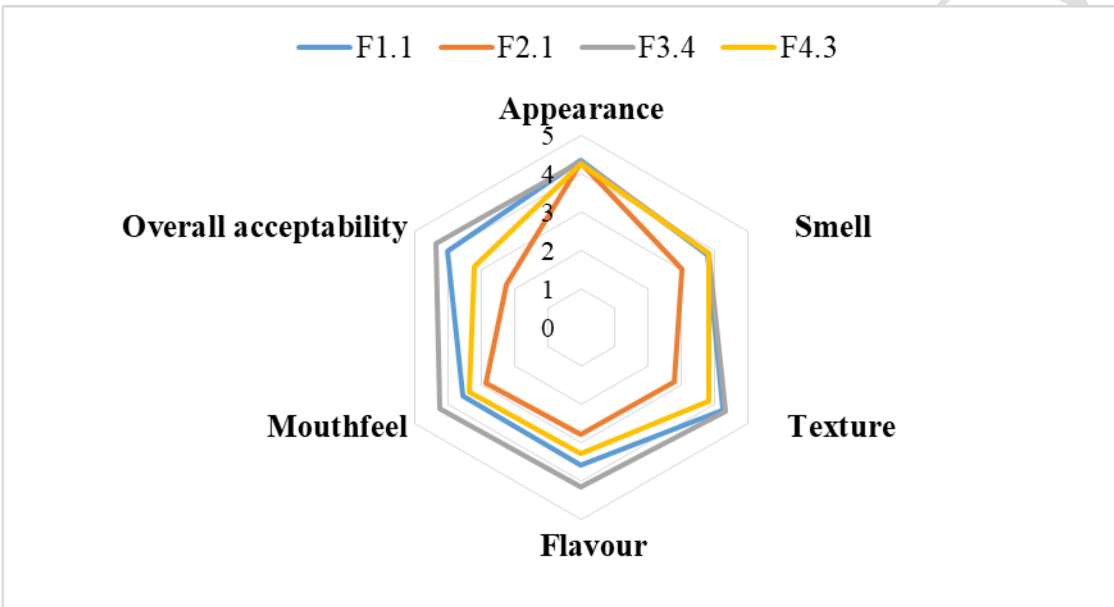

Figure 1: Sensory profiles of four composite flour formulations constructed using mean scores obtained for each sensory stimuli

The sensory profiles further illustrate in the figure 1 clearly portray that the best composite flour formulation is $F_{3.4}$ and least preference one is $F_{2.1}$. The second and third best flour formulations are coming out of $F_{1.1}$ and $F_{4.3}$ flour samples respectively.

The proximate composition of best four extruded flour formulations:

In order to determine the nutritional composition of extruded flour samples out of four sensorially best composite flour formulations ($F_{1.1}$, $F_{2.1}$, $F_{3.4}$ and $F_{4.3}$), they were subjected to proximate analysis and results are given in table 6.

Table 6: Proximate composition of best extruded composite flour formulations

Selected best formulation	Ash %	Fat %	Protein%	Dietary fiber %	Carbohydrate %
$F_{1.1}$	1.59 ± 0.02^{b}	4.96 ± 0.06^{e}	19.81 ± 0.02^{c}	8.98 ± 0.02^{b}	63.87 ± 0.02^{c}

$F_{2.1}$	2.30 ± 0.02^{a}	5.10 ± 0.01^{d}	20.09 ± 0.02^{b}	8.95 ± 0.05^{b}	63.98 ± 0.01^{c}
$F_{3.4}$	2.41 ± 0.02^{a}	6.01 ± 0.06^{c}	20.91 ± 0.03^{a}	9.20 ± 0.01^{a}	63.37 ± 0.02^{b}
$F_{4.3}$	2.36 ± 0.01^{a}	5.17 ± 0.06^{d}	19.94 ± 0.06^{c}	9.15 ± 0.03^{a}	65.15 ± 0.06^{a}
Market product	1.53 ± 0.05^{b}	6.91 ± 0.02^{b}	17.95 ± 0.05^{e}	6.98 ± 0.02^{d}	64.59 ± 0.05^{d}

Note: Data presented as Mean± Standard Deviation (n=3). Mean values in rows superscripted by different letters are significantly different at $p<0.05$ according to Turkey's multiple range tests. Results of the proximate composition analysis are presented on a dry weight basis.

According to the table 6, $F_{3.4}$ formulation contain the highest ash, crude fat, protein, crude fiber and carbohydrate contents comparative to the other 4 formulations developed by this study. Proximate compositions of the formulations were also compared with the similar products available in the local market which had been manufactured by using red rice as the major ingredient. In comparison with the market sample, the developed best formulation ($F_{3.4}$) contained significantly high ($p<0.05$) amounts of ash, protein, dietary fiber and carbohydrates as well as relatively low amount of fat.

Mineral content of best extruded products

Mineral content of four (4) best flour formulations were analyzed and compared with a leading brand available in the market and results are given in the table 7.

Table 7: Mineral composition of composite flour mixtures in mg/100 g

Selected best formulation	Ca	Na	Fe	Zn
$F_{1.1}$	800.12 ± 0.01^{d}	83.61 ± 0.01^{d}	5.53 ± 0.01^{c}	2.15 ± 0.01^{d}
$F_{2.1}$	840.70 ± 0.01^{c}	97.93 ± 0.02^{c}	5.97 ± 0.02^{b}	2.92 ± 0.02^{c}
$F_{3.4}$	940.28 ± 0.01^{b}	413.06 ± 0.01^{a}	6.73 ± 0.01^{a}	3.22 ± 0.04^{a}
$F_{4.3}$	1010.90 ± 0.02^{a}	275.60 ± 0.01^{b}	6.61 ± 0.05^{a}	3.07 ± 0.01^{b}
Market Product	190.58 ± 0.01^{e}	23.18 ± 0.04^{e}	5.60 ± 0.03^{c}	1.98 ± 0.01^{e}

Note: Data presented as Mean± Standard Deviation (n=3). Mean values in rows superscripted by different letters are significantly different at $p<0.05$ according to Turkey's multiple range tests.

The data given in table 7 demonstrate that sensorially best four flour formulations ($F_{1.1}$, $F_{2.1}$, $F_{3.4}$, and $F_{4.3}$) contained significantly higher amounts ($p<0.05$) of mineral than those of in the market sample according to this study. It is observed that $F_{4.3}$ formulation contained higher amounts of calcium than other formulations as well as against the market sample. Whereas, the formulation $F_{3.4}$ contained the highest amount of sodium (413.06 mg), iron (3.22mg) and zinc (3.22mg) per 100g than those of in $F_{1.1}$, $F_{2.1}$ and $F_{4.3}$ formulations. However, the market sample which has artificially been fortified with calcium and iron by incorporating calcium carbonate and ferric pyrophosphate respectively in order to increase the mineral content. Though the formulations developed in this study contain significantly higher amounts of calcium, sodium, iron and zinc than those of in the market sample. Nevertheless, the flour formulation "$F_{3.4}$" which was the most sensorially acceptable formulation contained the highest content of sodium, iron and zinc against other three (3) formulations formulated by this study.

Conclusion

Locally available grain varieties in Sri Lanka can be utilized to develop value added ready to eat products. In this study, traditional rice and some other locally available grains were utilized to develop a nutrient enriched precooked flour mixture. This can be used with a food supplement such as scraped coconut, fresh milk, sugar and water as consumer wish. According to this study, $F_{3.4}$ formulation was selected as the most acceptable formulations sensorially as well as nutritionally; because $F_{3.4}$ formulation contained more carbohydrate, protein, dietary fiber and ash than that of other formulations. Therefore, $F_{3.4}$ formulation (RF 50: GF 30: BF10: MF 35) was selected as the most preferable composite flour mixture for product development process. When comparing with a similar product available in the local market, the developed composite flour formulation having a higher percentage of carbohydrate, protein, dietary fiber and ash. Therefore, formulation $F_{3.4}$ can be promoted as a value-added supplementary product as it was developed by using local grain varieties as well as it has fortified with a rich nutritional profile.

Data availability

The raw data used to support the findings of this study are available from the corresponding author upon request

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