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Development of Dietary Fiber Rich Multi Legumes Flake Mix

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Abstract

Consumption of dietary fiber rich food has shown many health benefits against a range of disorders including obesity, type 2 diabetes mellitus and colon cancer. Total dietary fiber (TDF) is composed of two; soluble dietary fiber (SDF) and insoluble dietary fiber (IDF). Legumes are rich source of dietary fiber and resistant starch (RS). In addition, legume starch has low predicted glycemic index (pGI). This study was carried out to develop a dietary fiber rich multi legumes flake mix with low predicted glycemic index from selected legume varieties in Sri Lanka. Accordingly, 04 legumes such as mung bean, cowpea, soybean and horse gram were used. The multi legumes flake mix was prepared in 3 different formulae (F1, F2, and F3) by using sorghum (50%) as the base. Different legume proportions of soybean: horse gram: cowpea and mung bean in those formulae were F1–5%, 20%, 15%, 10%, F2–10%, 5%, 15%, 20% and F3–5%, 15%, 20%, 10% respectively. Sensory evaluation was carried out with 3 flavors; coconut milk+spices, coconut milk+sugar, milk powder+sugar for F1 formula. The taste and overall acceptability of three flavors were significantly different at $p<0.05$ and the spicy flavor had the highest mean score. Subsequently those three formulae were prepared in spicy flavor and those were analyzed for chemical composition and pGI value. Among 3 formulae, F1 had the highest TDF 13.84% (SD 0.08), highest RS 4.07% (SD 4.07) and the lowest pGI 33.52 (SD 0.11). The resistant starch content of three formulae showed inverse correlation with predicted glycemic index ($r=-0.936$, $p<0.05$). Accordingly, F1 formulation can be considered as the best formula for the preparation of dietary fiber rich multi legumes flake mix.

Keywords: Legumes; Multi legumes flake mix; Predicted glycemic index; Resistant starch; Total dietary fiber

Introduction

Dietary fiber has been defined as the plant cell polysaccharides and lignin not hydrolyzed by the digestive enzymes of animals and human [1] However, most appropriate term, which includes all ingested polymers in foods that are not broken down by digestive enzymes in the small intestine, is total dietary fiber (TDF) [2]. Therefore, Dietary fiber has a physiological effect on human health.

Resistant starch (RS) plays a major role in the healthy food industry, because it behaves with properties similar to soluble and insoluble dietary fiber in the gastrointestinal tract [3]. Resistant starch is a fraction of starch escapes enzyme hydrolysis in small intestine and pass to colon or large intestine [4].

However, starch origin and starch characteristics, as well as the ingredients and processing methods for starchy foods, are of great importance in altering the rate of hydrolysis *in vitro* and *in vivo* [3]. Indeed, raw legume starch has been shown to be less digestible than corn starch, and the rate of hydrolysis of legume starch *in vitro* is less than that of corn starch [5].

The magnitude of non-communicable diseases continues to rise all over the world. There is an increase in the spread of obesity, with exhibiting unique features of excess body fat, abdominal adiposity, increased subcutaneous and intra-abdominal fat and deposition of fat in ectopic sites. This could lead to complications like high cholesterol and triglycerides, heart disease, hypertension [6]. Foods with high glycemic index tend to release energy rapidly and raise blood sugar level at a fast rate. Such is undesirable in the diets of individuals with compromised health such as diabetics and other people may prone to diabetes. The other common diseases abundant among people are colon cancer, constipation and diverticulosis. As the number of people diagnosed with above diseases continues to increase around the world, nutritional approaches to disease prevention is one step to take to address this serious situation by formulating a product to optimize health [7].

By making the use of above vital nutritional properties in legumes, can be formulated healthy food products. Therefore, the present study was aimed to develop a dietary fiber rich multi legumes flake mix according to the previous data of legumes reported by Eashwarage et al.[8]. Since people spend a busy and sedentary lifestyle, they seek for convenient food and simultaneously demand is higher for healthy foods [9].

Materials and Methods

This study was conducted in four stages. At first stage, legumes and sorghum were prepared into flakes. At second, flakes were mixed according to proportions. Then a sensory evaluation was carried out with 3 flavors; coconut milk+spices, coconut milk+sugar, milk powder +sugar only for F1 formula. Finally, the three formulae were prepared with selected flavor and those were analyzed for their chemical composition and predicted glycemic index. Further, the correlation between resistant starch content and predicted glycemic index was determined.

Preparation of flakes

All seeds were screened for stones, rots and other defects and thoroughly washed and cleaned to remove the dust, and other foreign materials. After that they were soaked in water for required time period. The seeds and other particles that floated on water were removed and again the seeds were cleaned and washed well. Then those were drained and allowed to air drying for 10 min. After that those were blanched in boiling water for a sufficient time period and roasted at high flame while stirring for few minutes. The roasted seeds were put into flaking machine and the flakes were obtained. After that those were dried in a tray drier at 60ºC for 6 h. Finally, the cooled down samples were packed in high density polyethylene (HDPE) bags (Table 1).

Seed type	Time duration for soaking (h)	Time duration for blanching at 1000°C (min)	Time duration for roasting (min)
Sorghum	24	18	3
Horse gram	5	10	3
Soybean	8	20	4
Cowpea	6	5	4
Mung bean	6	5	5

Table 1: The requirements for flaking.

Preparation of three different formulae

By using the sorghum as the base (50%) three different formulae (F1, F2 and F3) were built up by adding different proportions of legumes (Table 2).

Seed type	Formula 1	Formula 2	Formula 3
Sorghum	50%	50%	50%
Horse gram	20%	5%	15%
Soybean	5%	10%	5%
Cowpea	15%	15%	20%
Mung bean	10%	20%	10%

Table 2: The composition of three formulae.

Sensory evaluation

Eleven trained sensory panelists were participated in sensory evaluation. The responses of respondents were recorded using nine point hedonic scale. They were instructed to evaluate three flavors of F1 formula with regards to given sensory characteristics such as appearance, odor, taste, mouth feel and overall acceptability and then indicate the intensity of the specified characteristics by giving the appropriate number related to the hedonic scale.

Compositional comparison among three formulae

The three formulae were prepared in the flavor which was accepted by the sensory evaluation. Moisture content was determined for each prepared fresh flakes samples. Then the samples were dehydrated by using domestic dehydrator at 60˚C for an overnight. After that all the above tests were done to determine the chemical composition and pGI of each formula. All the analysis was carried out in triplicates.

Moisture content was determined according to the oven drying method as described in AOAC 925.09B, applying gravimetric principle. Crude protein content was determined by micro-Kjeldahl method as specified in AOAC 920.87 using Kjeldahl heating digestion unit (VELP Scientifica DK 20) and Kjeldahl semi distillation unit (VELP Scientifica DK 139). Crude fat content was determined by soxhlet extraction method according to AOAC 920.39C using automatic extraction systems Soxtherm (C. GERHARDT GMBH & CO. KG Analytical Systems). Ash content was determined as specified in AOAC 923.03 by dry ashing method with gravimetric principle. Total carbohydrate content was determined according to the method described by Sompong [10].

The total dietary fiber (TDF) content was determined by enzymatic gravimetric method as specified in AOAC-991.42 official method of analysis. Resistant starch (RS) was determined using a kit assay (K-RSTAR, Megazyme international Ireland, Bray Business Park, Bray, Co. Wicklow, Ireland). This procedure has been subjected tointer-laboratory evaluation under the auspices of AOAC International and AACC International and accepted by both associations. Predicted glycemic index (pGI) was determined using the method described by Jenkins, et al. [11] with some modifications as described by Dahlin et al. [12].

Statistical analysis

Experimental data of sensory evaluation was statistically analyzed by Kruskal-Wallis test (non-parametric) analysis using SPSS 16.0 software. The data were statistically evaluated by one-way analysis of variance (ANOVA) by using Minitab 15 software and significant differences between means were determined by Turkey's multiple comparison. All test procedures were made at 5% significant level. Correlation between resistant starch and predicted glycemic index was determined by Pearson's correlation by using Minitab 15 software. The Microsoft Office Excel 2010 software was used to graphical representation of data.

Results

Sensory evaluation

Attribute	p value	Rank sums		
		592	231	873
Appearance	0.882	15.95	17.77	17.27
Odor	0.347	18.55	18.68	13.77
Taste	0.005*	24.41	13.59	13.00
Mouth feel	0.347	19.95	17.91	13.14
Overall acceptability	0.037*	22.82	15.00	13.18

*p<0.05; N=11

(Coconut milk+spicy mix (592), coconut milk+sugar (231) and milk powder+sugar (873)).

Table 3: Probability values and rank sums obtained by 592, 231 and 873 samples for sensory attributes.

A significant difference (p<0.05) was found only in two different attributes (taste and overall acceptability) for all three samples. Based on this, the sample 592 which obtained highest rank sum was selected as the most consumer acceptable flavor (Table 3).

Compositional comparison among three formulae

Formula	Moisture content (%) (Mean ± SD)	Protein content (%) (Mean ± SD)	Fat content (%) (Mean ± SD)	Ash content (%) (Mean ± SD)	Total carbohydrate%
F1	8.33 ± 0.02^{a}	19.88 ± 0.21^{b}	4.01 ± 0.08^{c}	5.28 ± 0.01^{a}	62.50
F2	7.55 ± 0.04^{c}	20.67 ± 0.13^{a}	4.56 ± 0.03^{a}	5.28 ± 0.02^{a}	61.94
F3	7.78 ± 0.01^{b}	19.91 ± 0.03^{b}	4.26 ± 0.04^{b}	5.23 ± 0.24^{b}	62.83

Values with different superscript letters within one column denote statistically significant differences (P<0.05).

Table 4: The proximate composition of three formulae.

According to above table there can be seen that high content of protein and fat in formula 2. That may be due to the higher incorporation (10%) of soybean flakes in formula 2 than in other two formulae (5%). In both formula 1 and 3 have approximately closer values of protein and fat. Because of relatively higher protein and fat levels, the total carbohydrate in formula 2 is lower than the other two formulae. There is a significant difference (p<0.05) in moisture and fat content of three formulae (Table 4).

Formula	TDF content (%) (Mean ± SD)	RS content (%) (Mean ± SD)	pGI (Mean ± SD)
F1	13.84 ± 0.08^{a}	4.07 ± 0.02^{a}	33.54 ± 0.11^{a}
F2	12.60 ± 0.50^{c}	3.04 ± 0.01^{c}	35.25 ± 0.08^{c}
F3	13.26 ± 0.30^{b}	3.91 ± 0.07^{b}	34.33 ± 0.07^{b}

Values with different superscript letters within one column denote statistically significant differences (P<0.05).

TDF: Total Dietary Fiber; RS: Resistant Starch; pGI: Predicted Glycemic Index

Table 5: The TDF, RS and pGI of three formulae.

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Table 5 shows that TDF and RS content in both formula 1 and formula 3 are higher than the formula 2. That may be due to the higher incorporation of horse gram in formula 1 and formula 3; 20% and 15% respectively. In formula 2 it was 5%. According to the results of previous study of Eashwarage, et al. [8], although soybean contains high amount of dietary fiber, it has very low amount of RS. Therefore the starch digestibility is high. As a result of that there might be seen higher pGI values too. In addition to that higher incorporation of soybean will cause weedy taste. Therefore here it has been used only up to 10%.

Starch hydrolysis % of three formulae

Starch digestibility % was analyzed for all three samples and the readings were taken at hourly interval for 3 h. The results show that the formula 1 has the lowest starch digestibility. It means that the contribution from formula 1 to the increase in blood glucose level is lower than the other two. Based on these results, formula 1 is the best in the meaning of health as it shown lowest value (Figure 1).

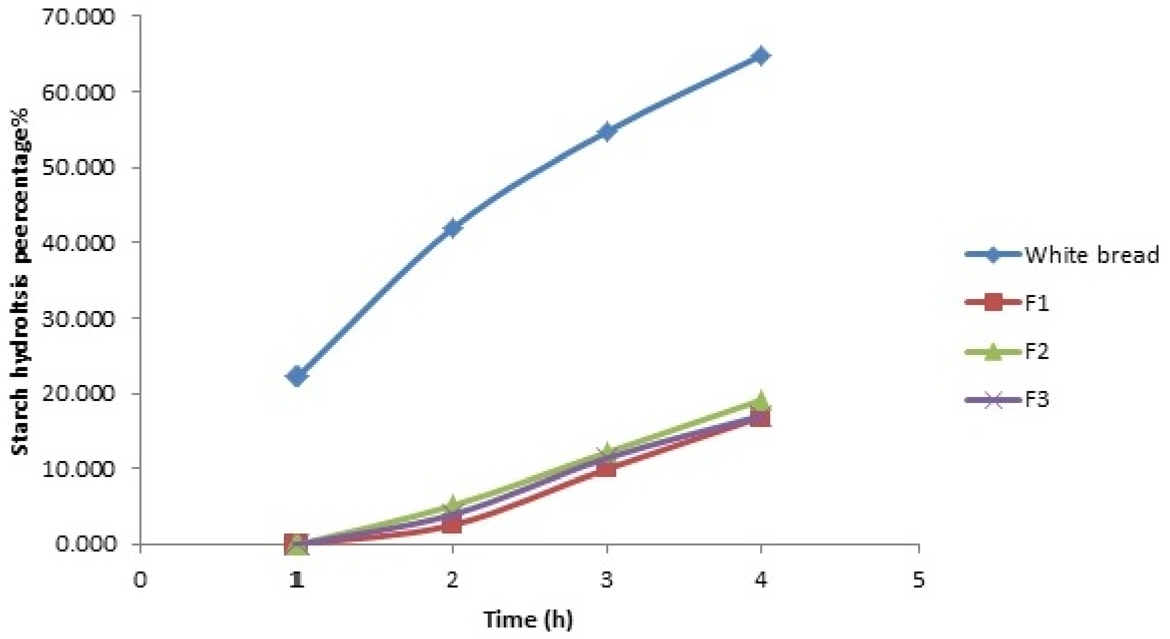

Figure 1: The starch hydrolysis for all three formulae over the time.

Determination of correlation between resistant starch (RS) content and predicted glycemic index (pGI) content of formulae

The Figure 2 shows that there is an inverse relationship between resistant starch and pGI (r=-0.936). This relationship is significant between RS and pGI ($p<0.05$). According to the findings of Odenigbo et al. [13], the increased resistant starch content results lower predicted GI value. The starch digestibility is affected by large number of intrinsic and extrinsic factors. Some of those intrinsic factors are starch structure, amylose: amylopectin ratio, lipid-starch complexes, protein-starch complexes, dietary fiber, anti-nutrient factors (tannin, lectin, phytic acid), type of starch etc. The degree of gelatinization or cooking methods, rigid cell walls, and retrogradation are some examples for the extrinsic factors. It is noted that not all starchy foods produce the same glycemic response [14]. Food with low carbohydrate will have high glycemic index if that carbohydrate is digest and absorb rapidly. That means, the digestibility of starch is varied according to the type of starch [15].

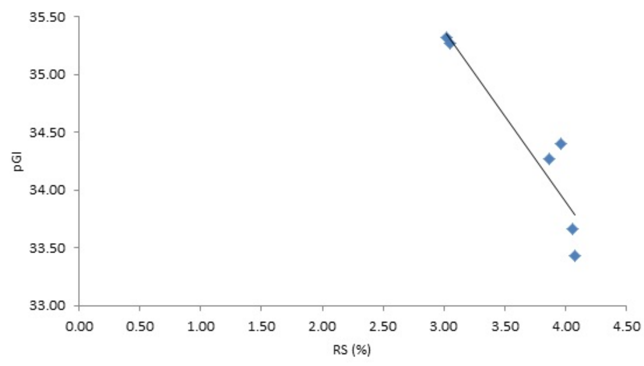

Figure 2: Correlation between resistant starch content and predicted glycemic index in three formulae.

Conclusion

Among the 3 formulae, F1 had the highest TDF 13.84% (SD 0.08), highest RS 4.07% (SD 4.07) and the lowest pGI 33.52% (SD 0.11).

Therefore, F1 formulation can be considered as the best formula for the preparation of dietary fiber rich multi legumes flake mix.

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