Characterization of cookies formulated with rice and black bean extruded flours

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ABSTRACT
The aim of this work was to formulate cookies using extruded flour from by-products of rice and common beans industries, such as broken rice and split old bean grains, in order to make available foods with added nutritional value as other options to consumers. The market of ready to eat and high quality products is increasing in the world considering the new habits and life style of modern consumers. Different proportions of rice and black bean (whole – WBF or peeled grain - PBF) pre-gelatinized flours were used to prepare the cookies by partially replacing the corn starch in the original recipe. The samples were characterized for physicochemical and sensory parameters. The final products showed an interesting nutritional composition. The increase of mixed flour on cookies formulation contributed to an increase of vitamin B content. There was no tannin content detected in the final products and the level of phytate was very low with no significant difference among samples. A significant difference between products was observed for some colour parameters. The sensory analyses showed that consumers “liked lightly” the cookies with 15% and 30% PBF and 15% WBF. Cookies formulated with WBF had lower acceptance by consumers in terms of appearance and only those with 30% WBF had an intermediate score (“neither like, neither dislike”) for global acceptability. Regarding texture, when a higher amount of both flour (PBF and WBF) was applied it was observed an increase of cookie hardness and fracturability values. In conclusion it is viable to produce acceptable cookies using a rice and black bean extruded flour and then diversify the application of these by-products generated by their processing industries.

Keywords: Extrusion; Oryza sativa; Phaseolus vulgaris; cookies; acceptability.

INTRODUCTION
White rice and common beans are considered staple food in Brazilian diet as an important source of good protein quality and energy [1, 2]. However, few actions are made with the by-products released from the rice milling or bean processing industries, especially at Brazilian market. On the other hand, the industrialized products of easy preparation as well as extruded foods have been developed under relatively low cost [3, 4].
The interest of Latin American countries on producing foods with high quality protein content has increased significantly, once this action may be a viable solution for the mal-nourish problems of their population. Children with this kind of deficiency show serious difficulties of physical and mental development, which can be irreversible in most cases [5].
Biscuits are bakery products of great commercial interest considering their production, commercialization and consumption characteristics, high demand, relatively long shelf life and good acceptability, particularly by children. These products are developed to implement formulations in nutritional terms, especially related to fibre and protein contents and may be an interesting vehicle for beans as an ingredient [6, 7].
It is known that the mixture of cereals and legumes can give a good protein balance and quality. So, the possibility of diversification of their application in food industries may expand and recover their consumption potential, especially for rice and beans.
When rice is milled, around 14% of broken grains are released and have similar composition of head rice but lower commercial value [8]. Most of this by-product, mainly the smallest rice grains, is used to make rice flour or as raw material to elaborate many kinds of foods by extrusion process [9, 10]. In the case of common beans, there is also the formation of broken or split grains, which generally become hard to cook when aging during storage [11] and receive a low price at the market. Due to the anti-nutritional factors present in beans

composition, it is necessary to submit the whole or split grains to some thermal process or cooking before consumption or transformation into flour as food ingredients.
These types of flours do not contain gluten, what is interesting to process alternative products for celiac or gluten intolerant people [8]. It is also proved that the mixture of rice and beans give a final protein content of better biological quality with an important amino acids balance, once the lysine amino acid that lacks in rice is present in beans, while sulphur amino acids present in rice can supply the beans deficiency. Besides, the combination of rice and beans provides a good source of several other nutrients [2].
Recently this concern has been increasing in the country since other successful examples can be observed in different parts of the world and our consumers are becoming more demanding for food diversity and quality. Extrusion cooking technology is increasingly being used for the development of food ingredients in order to promote the use of industrial wastes [12, 13].
In order to utilize valuable components of the broken rice and the aged split bean grains, which have low commercial value, to produce different bakery products, this study aimed to investigate the addition of a rice and black bean pre-gelatinized flour by extrusion on cookies formulations, composition and acceptability.

MATERIALS & METHODS

Production of pre-gelatinized rice and black bean flours

The peeled bean grains were obtained by soaking in hot water (40ºC) during 4 hours and drying at 80ºC in the oven during 3 hours, approximately. A soya bean dehuller was applied for mechanical peeling of bean. The samples were then milled using a knife and hammer mill until it reached the granulometry of 40 *mesh*. Mixtures of rice and peeled black bean (70:30) or whole black bean (60:40) were extruded on INBRAMAQ RX-50 extruder in order to produce pre-gelatinized flour (PBF and WBF respectively).
The extrusion parameters were set using temperatures between 120 and 125ºC; mixture moisture during processing set at 13.58% (WBF) and 16% (PBF); motor rotation speed set at 378 rpm; feeding rate of 33g/minute and circular matrix of 4mm.

Preparation of cookies

Four cookies samples were prepared varying the type and content of pre-gelatinized flour used: 15% and 30% PBF; 15% and 30% WBF; replacing corn starch, as shown in Table 1.

Table 1. Cookies formulations.

Ingredients (g)	15% WBF	15% PBF	30% WBF	30% PBF
Pre-gelatinized flour	150	150	300	300
Corn Starch	850	850	700	700
Fat	300	300	300	300
Sugar	350	350	350	350
Baking powder	20	20	20	20
Whole milk powder	50	50	50	50

WBF: rice and whole black bean pre-gelatinized flour; PBF: rice and peeled black bean pre-gelatinized flour.

Analyses of nutritional composition and anti-nutrient contents

The four cookies samples (15% and 30% PBF; 15% and 30% WBF replacing corn starch) were evaluated on nutritional composition according to AOAC [14] and dietary fibre through enzymatic method described by Freitas et al. [15] at Embrapa Rice and Beans. The thiamine (vitamin B_1) and riboflavin (vitamin B_2) were evaluated by HPLC according to the European Standard methods [16, 17]. Tannins concentration was determined based on Price et al. [18] and Deshpande and Cheryan [19] method description, using a methanol extraction and vanillin reaction with a catechin standard curve. Phytate content was determined according to Haug and Lantzsch [20] using a spectrophotometer (Femto) calibrated to visible absorbance range. The rice-black bean pre-gelatinized flours were also characterized for some of those parameters.

Instrumental hardness measurement

The texture characteristics of rice-black bean cookies in terms of hardness and fracturability were measured using a Stable Micro Systems TA-Hdi texture analyzer (Surrey, UK) fitted with a 5mm cylinder probe. Hardness value was considered as the area under the curve obtained and the linear distance was taken as an indication of fracturability. The studies were conducted at a pre-test speed of 1.0mm/s, test speed of 0.5mm/s. distance of 5.0mm, and load cell of 50 kg.

Colour measurements

Colour was evaluated by the CIEL*ch system (Colour Quest XE - Hunter Lab, USA). CIEL*ch is a modification to the CIELAB scale which plots in polar coordinates rather than rectangular ones. The colour attributes lightness (L*), chroma (C) and hue angle (h) were measured four times on the surface of the skin. Measurements were performed using 25mm viewing area aperture, D65 illuminant and 10° observer, according to CIE recommendations [21].

Sensory Acceptability

The sensory test was carried out in the Sensory Laboratory of the Embrapa Food Technology. Consumers (104) were recruited from students and workers from administrative and technical staff of Embrapa. Consumers were selected according to their liking and consumption frequency of this kind of products. They were 48% women and 52% men, and their ages ranged between 18 and 55 years.

Consumers evaluated four cookie formulations regarding to “overall liking” and “appearance” acceptability on 9-point hedonic scales. The samples were monadically served at room temperature in porcelain dish, codified with 3 digit numbers in individual booths under white light. The presentation order followed a balanced complete block design.

Data Analyses

Data were analyzed by ANOVA and significant differences among samples were assessed using the Fisher (LSD) test ($p <0.05$) in XLSTAT software or Tukey test ($p < 0.05$) with SAS [22].

RESULTS & DISCUSSION

The final products showed an interesting nutritional composition as shown in Table 2. The cookies moisture values fit the determination of Brazilian legislation by CNNPA resolution n°12, 1978 [23], where biscuits must have maximum moisture of 14%. The rice and bean cookies had lower moisture than control one, what can influence their crispy and stability characteristics.

The final formulations presented higher carbohydrates contents especially when whole bean grain was used in the flour. So, the cookies can be considered a good source of energy. The rice and bean cookies had an average of 435 Kcal/100g of energetic value, which is around 9% lower than control, probably due to their less fat content. This is considered a high value and so, the cookies can be applied in the diet as energetic products.

The protein content was significantly higher (about 2-fold) for all samples in comparison to control and to cookies made of wheat flour [24], what can be attributed to beans addition, which have higher protein content than cereals. Once the main base of cookie protein comes from cereal sources (corn and rice) and also considering the cooking processes of the products (flour extrusion and baking) it is expected that the protein content is reduced if compared to other cookies, such as soya-based ones [25]. According to Brazilian resolution for Daily Ingestion Recommendation (DIR) of protein (RDC n.º 269, September 22, 2005), it is recommended the ingestion of 19 g protein/day for children from 4 to 6 years-old. Based on Brazilian Ordinance nº 33, January 13, 1998, the average protein content found for rice and bean cookies (3.64%) allows us to affirm that these products is a source of protein for children, because they attend the demanded minimum percent of 20% of reference DIR for each 100 g of food [26, 27].

Generally cookies present high fat concentration in their composition as a consequence of addition of hydrogenated fat. The lipid content was lower in the rice-bean cookies than control, especially for 30% of corn starch substitution and when whole beans were used. The fat content was also interestingly lower than soya bean-based cookies [25], once the rice and beans have originally very low lipids contents.

During rice milling process, the bran is removed as well as most vitamins and minerals [28]. So it is expected a low content of vitamin B complex in rice flour. Water soluble vitamins, such as thiamin and riboflavin, are sensible to high temperature. The extrusion and baking processes might also have reduced vitamin B concentration in cookies. When flour had more beans in the mixture, the thiamin content was higher, especially when using whole bean grains. The increase of rice and whole bean mixed flour on cookies formulation practically kept the vitamin B contents when compared to the control sample. When peeled beans were applied it was observed a slightly decrease of thiamine content in cookies. There was no tannin content detected in the final products and the level of phytate was very low with no significant difference between products (Table 2). This observation indicates that extrusion process contributed to reduce anti-nutritional factors. The low concentrations of phytic acid and phenolic compounds may have positive effects on human health with a protection or prevention action against cancer and some heart diseases [29, 30].

Table 2. Proximal composition (%) and anti-nutrients contents (%) of samples.

Sample	Moisture	CHO	PRO	LIP	ASH	TDF	PHY	TAN
Cookie with 100% corn starch (control)	6.70±0.13^{a}	81.10±0.44^{d}	1.81±0.21^{c}	16.21±0.22^{a}	0.82±0.02^{c}	0.85±0.72^{a}	0.004±0.00	nd**
Cookie with 30% PBF	5.16±0.00^{b}	83.74±0.06^{c}	3.89±0.10^{a}	9.69±0.03^{c}	1.02±0.00^{b}	2.03±0.17^{a}	0.036±0.00	nd
Cookie with 15% PBF	5.20±0.09^{b}	83.72±0.16^{c}	3.83±0.07^{a}	10.69±0.07^{b}	1.11±0.02^{a}	2.07±0.98^{a}	0.048±0.01	nd
Cookie with 30% WBF	5.06±0.04^{b}	85.72±0.05^{b}	3.87±0.13^{a}	7.29±0.08^{e}	1.07±0.00^{ab}	2.06±0.42^{a}	0.048±0.06	nd
Cookie with 15% WBF	5.41±0.37^{b}	87.06±0.00^{a}	2.95±0.02^{b}	7.98±0.01^{d}	1.06±0.01^{ab}	1.70±0.54^{a}	0.050±0.03	nd
Pre-gelatinized flour (70% rice + 30% peeled black bean)	5.33±0.11	81.28±0.14	13.86±0.11	0.03±0.00	1.69±0.01	3.15±0.02	0.357±0.01	nd
Pre-gelatinized flour (60% rice + 40% whole black bean)	6.08±0.00	74.05±0.05	14.18±0.01	0.14±0.01	2.02±0.11	9.61±0.02	0.363±0.02	0.097±0.01

*CHO = carbohydrates; PRO = proteins; LIP = lipids; TDF = total dietary fibre; PHY = phytates; TAN = tannins. **nd – not detectable. Data are on dry basis. Values for cookies (means ± standard deviation) with different superscripts within column are significant different by Tukey test ($p<0.05$).

Table 3 presents the results of colour attributes and texture measurements found on the rice and black bean formulating cookies.

Table 3. Colour attributes (L*- lightness, C – chroma, h – hue angle) and texture measurements for cookies containing rice and black bean extruded flour.

	Colour			Texture	
	L*	C	h	Hardness (g.s)	Fracturability
15% PBF	76.85±2.48^{a}	21.46±1.18^{b}	82.63±1.14^{a}	1118.65±537.5^{b}	1.09±0.47^{a}
30% PBF	74.29±2.11^{ab}	23.59±0.97^{a}	76.76±0.84^{b}	1440.52±376.4^{b}	1.11±0.64^{a}
15% WBF	77.64±0.26^{a}	14.01±0.92^{c}	82.64±1.15^{a}	1374.54±292.2^{b}	0.79±0.54^{a}
30% WBF	70.77±2.94^{b}	15.25±0.19^{c}	78.16±1.09^{b}	2665.45±507.2^{a}	0.91±0.53^{a}

PBF: rice and peeled black bean pre-gelatinized flour; WBF: rice and whole black bean pre-gelatinized flour; Values (means ± standard deviation) with different superscripts within column are significant different according to Fisher (LSD) test ($p<0.05$).

There was significant difference between products for some colour parameters. The lightness (L*) for cookies containing 15% of pre-gelatinized flours (PBF and WBF) was no different ($p>0.05$) statistically (76.85 and 77.84, respectively). However, all treatments showed a decrease in lightness (L*) according to increase on pre-gelatinized flour content (Table 3). Cookies formulated with rice and whole black bean pre-gelatinized flour (WBF) showed higher rates of L* changes.

The chroma (colour intensity) of the cookies depended on the type of flour utilized. Cookies formulated with rice and whole black bean pre-gelatinized flour (WBF) presented lower ($p<0.05$) values to this attribute, but there was no change with the increase of its content.

Hue angle gives a numerical estimate of the colour of the cookies. The hue sequence on a CIELAB diagram is defined with red-purple (0°), yellow (90°), bluish-green (180°) and blue (270°) [31]. Both cookies containing 15% of pre-gelatinized flours (hue angles of 82.6°) showed higher hue angles than those containing 30% of pre-gelatinized flours (hue angles of 76.7° and 78.1° for PBF and WBF, respectively). Decrease in hue angle values were observed according to increase of flour content on formulation, with the cookies becoming less orange/yellow (Table 3). Differences in hue angle could be attributed to interaction of some pigments of pre-gelatinized flours with other compounds in the formulation. The coloured compounds of black bean grains may have contributed to the final colour of the cookie.

Regarding texture measurements, the cookies prepared with 30% WBF presented highest ($p<0.05$) hardness and fracturability values. In general, when a higher amount of both flour (PBF and WBF) was applied on formulation it was observed an increase of cookie hardness and brittleness values.
The sensory analyses showed that consumers “liked lightly” the cookies with 15% and 30% PBF and 15% WBF (Table 4). Cookies formulated with WBF had lower acceptance by consumers in terms of appearance and only those with 30% WBF had an intermediate score (”neither like, neither dislike”) for global acceptability.

Table 4. Average liking scores (± standard deviations) for cookies containing rice and black bean extruded flour.

	Appearance	Overall liking
15% PBF	6.14 ± 1.84^a	6.25 ± 1.92^a
30% PBF	6.21 ± 2.01^a	6.17 ± 1.70^a
15% WBF	4.33 ± 2.17^b	6.09 ± 2.17^a
30% WBF	4.41 ± 2.22^b	5.39 ± 2.15^b

PBF: rice and peeled black bean pre-gelatinized flour; WBF: rice and whole black bean pre-gelatinized flour.

CONCLUSION

The obtained results indicate that both PBF and WBF flours may be adequate for cookies formulating, although they need to be optimized, especially when whole bean grain was used in the flour, regarding their effect on sensory characteristics. The cookies using rice and black bean extruded flours can be considered a good source of protein, fibre, energy and presented reduced anti-nutritional factors and lipid content, making possible to diversify the application of by-products generated by rice and black bean processing industries.

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