Processing and technological characterization of extruded breakfast cereal obtained with a mix of broken rice and common bean flour

Carvalho, A.V.[a], Bassinello P.Z.[b], Rios, A. de O.[c]

[a] *Embrapa Eastern Amazon, Belém, Brazil (anavania@cpatu.embrapa.br)*
[b] *Embrapa Rice and Beans, Goiânia, Brazil (pzbassin@cnpaf.embrapa.br)*
[c] *Federal University of Rio Grande do Sul, Porto Alegre, Brazil (alessandro.rios@ufrgs.br)*

ABSTRACT

The aim of this work was to evaluate the functional technological properties of breakfast cereal obtained with a mix of broken rice and common bean flour, by the analyses of expansion index, water absorption index, water solubility index, apparent density, viscosity and instrumental texture. The product was elaborated with a rice and common bean mixed flour, using the proportion of 70% broken rice flour and 30% of broken common bean flour. The tested formulation was processed in a single-screw extruder. The extrusion parameters were set using three extrusion zones with temperatures of 40°C (1st zone), 60°C (2nd zone) e 80°C (3rd zone); mixture moisture during processing set at 14%; screw speed set at 177 rpm; feeding rate of 290g/minute and circular matrix of 3.85mm. The developed breakfast cereal was sprinkled with a sufficient quantity of a 70 ºBrix sucrose solution to make a final product with approximately 35% sugar. The processed formulation was manually collected, submitted to a forced air circulation oven drying and, afterwards, it was stored in polyethylene bags until analyses. The extruded obtained showed relatively low values for water absorption index (6.41g gel/g dry matter) and high values for water solubility index (44.50%). The expansion index of breakfast cereal was 8.89 indicating a good expansion of the final product. For apparent density it was observed the value of 0.25 and for instrumental texture evaluation, the value of 1,087.44g. The paste viscosity is an important attribute to study the functional properties of starchy food. Severe treatments destroy the starch granular structure, reducing the paste viscosity, what can be observed in this work through viscosity values below 130cP. It can be concluded that the use of broken common bean and rice mixed flour is an alternative to elaborate extruded breakfast cereal with good technological properties.

Keywords: *thermoplastic extrusion; breakfast cereal; broken common bean; broken rice; technological properties.*

INTRODUCTION

The consumption of breakfast cereals has increased in recent years due to the need to obtain products of rapid preparation, in view of the lack of time in modern life. Breakfast cereals are extruded products, traditionally eaten with milk which have starch as main component.

On the other hand, certain combinations of cereals and leguminous can be quite desirable from a nutritional standpoint, because of complementation of essential amino acids and an increase in protein content. The mixture of rice and beans is a good nutritional mix, providing energy and essential amino acids required in a healthy diet and provide substantial amounts of vitamins, minerals and fiber [1].

When rice is milled, 14% of broken grains are released and the smallest ones have similar composition of head rice but lower commercial value [2]. Most of this byproduct is used to make rice flour and as raw material to elaborate many kinds of foods by extrusion process [3, 4]. In the case of common beans, there is also the formation of broken grains, which generally are hard to cook and receive a low price at the market. They are popularly called “bandinha” in Portuguese, which in turn can be transformed in flour for food purposes. These types of flours do not contain gluten, what is interesting to process alternative products for celiac or gluten intolerant people [2].

Considering that the lack of good quality protein and calories in a diet can result in a generalized malnutrition, then there is the possibility of exploiting the rice and beans through the processing by extrusion cooking, with the possibility of obtaining products with good quality technological, nutritional and sensory.

The aim of this work was to evaluate the functional technological properties of breakfast cereal obtained with a mix of broken rice and common bean flour, by the analyses of expansion index, water absorption index, water solubility index, apparent density, viscosity and instrumental texture.

MATERIALS & METHODS

The breakfast cereal was elaborated with a rice and common bean mixed flour, using the proportion of 70% broken rice flour and 30% of broken common bean flour. The tested formulation was processed in a single-screw extruder, from INBRAMAQ, model Labor PQ30 (Ribeirão Preto, Brazil), whose configuration and interchangeable screws are appropriate to produce expanded products. The extrusion parameters were set using three extrusion zones with temperatures of 40°C (1st zone), 60°C (2nd zone) e 80°C (3rd zone); mixture moisture during processing set at 14%; screw speed set at 177 rpm; feeding rate of 290g/minute and circular matrix of 3.85mm. The developed breakfast cereal was sprinkled with a sufficient quantity of a 70 ºBrix sucrose solution to make a final product with approximately 35% sugar. The processed formulation was manually collected, submitted to a forced air circulation oven drying and, afterwards, it was stored in polyethylene bags until analyses.

In order to characterize some technological performance of the breakfast cereal the following analyses were performed: apparent density [5], radial expansion index [6], water absorption and water solubility indexes [7], pasta viscosity (determined by the "Rapid Visco Analyser (RVA)", according to the method for extruded materials) and instrumental texture. It was used the texture analyzer Stable Micro Systems model TA.XT Plus (Surrey, England) with load cell of 50kg, cylindrical compression device of 2mm and ten repetitions.

RESULTS & DISCUSSION

The results for the technological characterization of the breakfast cereal of rice and beans are presented on Table 1.

Tabela 1. Results of means and standard deviation for apparent density, expansion index and instrumental texture of the breakfast cereal of rice and beans.

Apparent density	Expansion index	Water absorption index (g/g)	Water solubility index (%)	Texture (g.f)
0.25±0.00	8.89±0.14	6.41±0.13	44.50±0.14	1,087.44±220.44

The apparent density is an important physical characteristic in extruded products, because it directly interferes on the package and, consequently, on the final product cost. It can vary as a function of different parameters such as moisture, extrusion temperature, formulation and raw material composition in terms of fiber, protein and starch contents [8].

Indirectly, it is possible to quantify the extrusion process efficiency through apparent density and, objectively, to evaluate how light or heavy the elaborated extruded products are, and thus, to predict the consumers acceptability [9].

For extruded expanded breakfast cereals it is necessary to obtain products with a higher apparent density, lower porosity and thicker wall structure when compared with snacks processed by extrusion, once those products will be submitted to an immersion on liquid or aqueous medium, for example, milk, and have to keep their texture during the longest possible period with the lowest moisture absorption [10].

The breakfast cereal of broken rice and common beans showed an apparent density of 0.25 similar to the values related by Ascheri et al. [8], who studied expanded products made of whole amaranths and broken rice flours, and depending on the process conditions, reported values varying from 0.13 to 0.68; and by Oliveira [11] Who observed values from 0.18 to 0.92 for expanded extruded products of soya bean peel and corn.

The expansion index is a measure that allows one, at first, to predict how severe or light the extrusion process was [12]. Chiang & Jhonson [13] said that this index is related to the gelatinization level that occurs during the process and to the water vaporization rate when the product leaves the matrix.

The rice and beans breakfast cereal showed an expansion index of 8.89, a value superior to those related by Vernaza et al. [14] for breakfast cereal formulated with passion fruit bran and corn flour (1.02 to 4.11); and by Camargo et al. [15] for extruded biscuits of sour cassava starch powder with fibers (3.5 to 5.7). The high value of the present work is found due to the fact that extruded rice has high starch content and, according to Mercier et al. [10], the maximum expansion degree is closely related to the starch level, being the maximum expansion obtained with pure starches.

During the extrusion process, the raw material undergoes diverse chemical and structural changes, so that starch is one of the components suffering the greatest transformations. The water absorption (WAI) and water solubility (WSI) indexes are parameters that help to measure the transformation degree suffered by the amylaceous fraction of the extruded materials [16]. The rice and beans breakfast cereal had a WAI of 6.41g/g and WSI of 44.50% (Table 1). The WAI obtained is close to that observed by Steel [17] for rice and beans mixed extruded flour, of 7.8g/g sample. The author also noticed that these flours presented an increase of this index in relation to pure common bean flour, what can be attributed to the increase of starch fraction as a function of rice flour addition. On the other hand, Clerice and El-Dash [4] found a WSI of 15.92% for broken rice, a value below the one of the present work. This difference can be explained by the different processing conditions adopted by the works, or even by the addition of common bean flour, which can have contributed to the increase of WSI of the pre-gelatinized rice and bean flour.

The texture is a critical factor for the quality of crispy and expanded products. It can be described as a compressive deformation of solids under high pressure. The mechanical properties of foods under high compression rates are related to the sensory property of crispness, due to the high strain rate provoked by chew [10]. The hardness and crispness are consumer perceptions and are associated to the expansion and cell structure of the extruded products [18].

In the case of breakfast cereals it is necessary a more closed or compact structure to avoid the rapid moisture absorption (for milk immersion). The rice and beans breakfast cereal had a hardness value of 1087.44g.f, similar to that verified for *snacks* of yams flour [19] which varied from 757.43g.f to 1210.7g.f. On the other hand, Vernaza et al. [14] studied different process conditions to elaborate breakfast cereal of passion fruit bran and corn flour and found a wide range for hardness, from 954g.f to 2623.73g.f, being that the lower values of this range were close to the ones of the rice and beans breakfast cereal and were observed under conditions of lowest moisture of raw material and lowest dietary fiber content. Mercier et al. [10] said that fibers generally reduce the product expansion due to the rupture of cell walls before the gas bubbles expand to the maximum size, resulting in hard, compact and not crispy products, with undesirable sensory texture.

In Figure 1 it is presented the viscosity pattern of the rice and beans breakfast cereal.

The paste viscosity is an important attribute to study the functional properties of starchy food, being one of the ways to evaluate the degradation degree that occurs in these materials during thermal treatment. Severe treatments destroy the starch granular structure, reducing the paste viscosity, what can be observed in this work through viscosity values below 130cP.

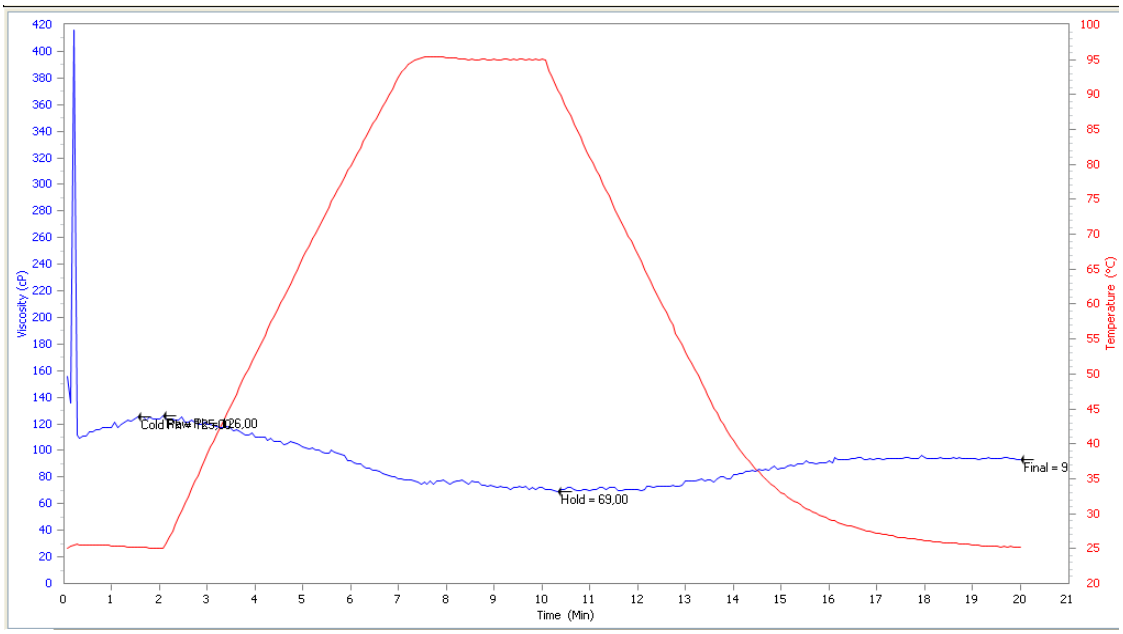

Figure 1. Viscosity profile of rice and common bean breakfast cereal.

CONCLUSION

It is possible produce extruded breakfast cereal using the proportion of 70% broken rice flour and 30% of broken common bean flour and the final product shows good technological properties.

REFERENCES

[1] Pires, C.V. Oliveira, M.G.A.; Rosa, J.C.; Costa, N.M.B. 2006. Qualidade nutricional e escore químico de aminoácidos de diferentes fontes protéicas. Ciência e Tecnologia de Alimentos, 26(1), 179-187.

[2] Silva, R.F.; Ascheri, J.L.R. 2009. Extrusão de quirera de arroz para uso como ingrediente alimentar. Brazilian Journal of Food Technology, 12(3), 190-199.

[3] Dors, G.C.; Castiglioni, G.L.; Ruiz, W.A. 2006. Utilização da farinha de arroz na elaboração de sobremesa. Vetor, 16, 63-67.

[4] Clerici, M.T.P.S.; El-Dash, A.A. 2008. Características tecnológicas de farinhas de arroz pré-gelatinizadas obtidas por extrusão termoplástica. Ciência e Agrotecnologia, 32(5), 1543-1550.

[5] Ramirez, J.L.A.; Wanderley, C.P. 1997. Effect de los parametros de extrusion, caracteristicas de pasta y textura de pellets (snacks de terceira generacion) producidos a partir de trigo y maiz. Alimentaria, 279(1), 93-98.

[6] Alvarez-Martinez, L.; Kondury, K.P.; Harper, J.M. 1988. A general-model for expansion of extruded products. Journal of Food Science, 53, 609-615.

[7] Anderson, R.A.; Conway, H.F.; Pfeifer, V.F.; Griffin, L. 1969. Gelatinization of corn grits by roll and extrusuion cooking. Cereal Science Today, 14(1), 4-11.

[8] Ascheri, J. L.; Mendonça, X. M. F. D.; Ascheri, D. P. R.; Maia, M. C. A. 2005. Extrusão de harina mixta de amranto integral y arroz: Parte I. Caracterización físico-química. Alimentaria, 367, 74-83.

[9] Carvalho, A.V.; Vasconcelos, M.A.M.; Silva, P.A.; Assis, G.T.; Ascheri, J.L.R. 2010. Caracterização tecnológica de extrusados de terceira geração à base de farinhas de mandioca e pupunha. Ciência e Agrotecnologia, 34(4), 995-1003.

[10] Mercier, C.; Linko, P.; Harper, J.M. 1998. Extrusion cooking. 2 ed. St. Paul: American Association of Cereal Chemists, 199 p.

[11] Oliveira, G.D. 2007. Obtenção de produtos extrusados expandidos e não-expandidos de casca de soja e milho. 104 f. Dissertação (Mestrado em Ciência e Tecnologia de Alimentos) – Instituto de Tecnologia, Universidade Federal do Rio de Janeiro, Seropédica.

[12] Lusas, E; Riaz, M. 1994. An introduction to extruders and extrusion principles. Extrusion Communiqué, 9-34.

[13] Chiang, B. Y. Jhonson, J. A. Gelatinization of the starch in extruded products. 1977. Cereal Chemistry, 54(3), 436-443.

[14] Vernaza, M.G.; Chang, Y.K.; Steel, C.J. , 2009. Efeito do teor de farelo de maracujá e da umidade e temperatura de extrusão no desenvolvimento de cereal matinal funcional orgânico. Brazilian Journal of Food Technology, 12(2), 145-154.

[15] Camargo, K.F; Leonel, M; Mischan, M.M. 2008. Produção de biscoitos extrusados de polvilho azedo com fibras: efeito de parâmetros operacionais sobre as propriedades físicas. Ciência e Tecnologia de Alimentos, 28(3), 586-591.

[16] Camire, M.E. 2000. Chemical and nutritional changes in food during extrusion. In: Riaz, M.N. Extruders in food applications. CRC PRESS.

[17] Steel, J.C. 1994. A influencia da extrusão termoplástica em propriedades funcionais e nutricionais de farinhas de feijão e farinhas mistas de feijão com arroz. 119p. Dissertação (Mestre em Ciência da Nutrição). Universidade Estadual de Campinas, Campinas, São Paulo.

[18] Ding, Q; Ainsworth, P.; Plunkett, A.; Tucker, G.; Marson, H. 2005. The effect of extrusion conditions on the physicochemical properties and sensory characteristics of ricebase expanded snacks. Journal of Food Engineering, 66, 283-289.

[19] Alves, R.M.L; Grossmann, M.V.E. 2002. Parâmetros de extrusão para produção de “snacks” de farinha de cará (*Dioscorea alata*). Ciência e Tecnologia de Alimentos, 22(1), 32-38.