PROCESSING AND CHARACTERIZATION OF READY TO EAT CO-FILLED SINGLE SCREW EXTRUSION TECHNOLOGY

Bellal Hossain, Moonmoon Huq

Dept. of Nutrition and Food Engineering
Daffodil International University

Email: drbellal@daffodilvarsity.edu.bd, moonmoonhuq@daffodilvarsity.edu..bd

Abstract: *Breakfast cereals are very popular, and globally their consumption is growing, thanks to continuous product innovation. The product was elaborated with a rice and maize grit, using the proportion of 40% rice grit and 45% of maize grit including additional functional ingredients. The sample formulation was processed in a single-screw extruder at AHZ Agro Industry Pvt Ltd from 2009 to 2010. The extrusion parameters were set at temperatures of 180°C to 200°C; mixture moisture during processing set at 20%; screw speed set at 180 rpm; feeding rate of 2033gm/minute and circular matrix of 3.5mm. The developed extrusion sample was filled with chocolate cream using injection nozzle. The formulated ingredients were manually collected, dried to a forced air circulation oven dryer. The result of extruded sample showed 6.41g /g water absorption, 44.50%water solubility, and 8.89 expansion values. The bulk density was 0.25 gm/cc and 1,087.44g of instrumental texture evaluation for the sample was obtained. The paste viscosity was 130 c_p at 45 °c was an important attribute to study the functional properties of sample. The aim of this work was to evaluate the operational technological aspects of extrusion ready to eat nutritious snacks obtained with a mix of rice grit, corn grit, cocoa powder and food grade additives, by the analyses of expansion value, water absorption , water solubility , bulk density, viscosity and sensory . Proximate values of the extruded cookie byte was 2.5% moisture, 11.6 % fat, 8% protein , 75% carbohydrate , 1.7% ash, 1.25% dietary fiber and 475mg Ca in percentile respectively. It can be concluded that the use of rice and maize grit to elaborate extruded cookie byte snacks with good technological properties.*

Keywords: *Single screw extrusion; cookie byte; rice grit; maize grit; technologica Properties, bulk density*

1. 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. The popularity of breakfast cereals really stems from their nutritional content. Such products can simultaneously provide energy (400-500 kcal/100g) [11], comfort and pleasure, nutrients (vitamins, minerals) and health-oriented components (dietary fiber). Over the last three decades, Extrusion technology has played a very important and decisive role in the innovation and development of breakfast cereals products. It allows continuous cooking and texturization of a large range of recipes, to produce large diversity of textures, shapes, tastes and colors, as well as to optimize the nutritional content and health benefits of finished products. The extrusion processing of breakfast cereals permits to produce other value-added products such as co-filled pillows and snacks to the process flexibility. The consumption of extruded snacks has increased in recent years due to the need to obtain products as ready to eat form, in view of the lack of time in modern life. Ready to eat snacks are extruded products, traditionally eaten with milk or sweet syrup or honey or spices which have starch as main component. On the other hand, certain combinations of cereals, chocolate cream and fiber can be quite desirable from a nutritional standpoint, because of complementation of dietary fiber and an increase in trace element content. The mixture of rice grit, corn grit, spices extract, and mineral premix is a good nutritional mix, providing energy, fiber, and trace element required in a healthy diet [11]. When rice and maize are milled, 14%-20% of broken grains are released and the smallest ones have similar composition of head cereal but lower commercial value. Most of this byproduct

Date of submission : 31.07.2013 Date of acceptance : 21.11.2013

is used to make rice/maize grit and as raw material to elaborate many kinds of foods by extrusion process [2,3,4]. 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 research works were conducted at the AHZ Agro Industry Pvt Ltd. Gazipur, Bangladesh from the year 2009 to 2010 under snacks food unit. The aim of this work was to evaluate the functional technological properties of breakfast cereal type cookie byte obtained with a mix of rice and maize grit, by the analyses of expansion value, water absorption and water solubility index, bulk density, viscosity and instrumental texture.

2. Materials And Methods

2.1. Materials

In this application, rice grit (12% moisture), maize grit (12.4% moisture), cocoa powder (10%, fat), common salt and baking soda were used for extruded product. For co-filling, chocolate cream was prepared using skimmed milk powder, HPK Oil, whey powder, crushing sugar, and emulsifying agent. All raw materials were collected from local market of Bangladesh.

A. Table 1 Formulation for extruded snacks Cookie byte Extruded Snacks

Sl No	Ingredients	Weight In %
	Corn grits (250 mesh)	45.00
	$CaCO_3$ powder	0.10
	Cocoa powder	2.00
	Vegetable Oil	0.20
	Water	4.00
	Rice grit	40.0
	Salt	1.20
	Icing Sugar	7.60
	$NaHCO_3$	0.10
	Total Amount	100%

B. Core filled cream

Sl No	Ingredients	Weight In %
1	CBS Fat 33 ~ 35°C As Lauric	32.00
2	Coating fat 42°c as lauric	7.00
3	Alkalized cocoa powder	6.00
4	Cocoa mass	2.00
5	Skim milk powder	8.00
6	Whey powder	5.00
7	Icing sugar	39.00
8	Soy lecithin	0.50
9	Salt	0.40
10	Vanillin powder	0.10
11	Chocolate Flavor	0.10
12	Calcium Sorbet	0.01
	Total Amount	100%

2.2 Quality parameters

Such as the texture are often dependent on the viscosity. The influence of extruder variables like screw speed, die geometry, screw geometry and barrel temperature on the product quality has been described by numerous authors for [5-10]. Proximate analysis was done as per AOAC (11) manual. Statistical analysis of the physico mechanical data of sample was calculated using SAS version-15.

3.1 Engineering Methods

Extrusion processing of food materials has become an increasingly important manufacturing method. The processing consist of several steps including fluid flow, heat , mass transfer, mixing shearing , particle shape reduction ,melting, texturizing, caramelizing, plasticizing, shaping , forming , core filling and cooling . After than pouching through tunnel conveyor hopper to multihead packaging machine. Food extrusion processing is a high temperature short time process with 180 to 200 °C at 10 Sec[2].

In principle, the effect of these melting parts is based on improved mixing. This mixing effect can be based on particle distribution or on shear effects exerted on product particles. For distributive mixing the effects of mixing are

believed to be proportional to the total shear λ given by:

$$\lambda = \int_0^t \frac{dy}{dx} dt$$

Whereas for dispersive (shear) mixing the effect is proportional to the shear stress $\mathcal{T}$:

$$\mathcal{T} = \mu \frac{dy}{dx}$$

The group of distributive mixing screws can be divided into the pin mixing section [5,6,7] is used for food in the co-kneader. The amount of mixing and shear energy is simply controlled by varying the number of pins.

3.2 Rheological Considerations

A major complication is that chemical reactions also occur during the extrusion-cooking process which strongly influences the viscosity function. The rheological behavior of the product, which is relevant to the modeling of the extrusion process, has to be defined directly after the extruder screw tip, before expansion has occurred, in order to prevent the influence of water losses.

It is well known that within normal operating ranges starches materials are shear thinning. This justifies the use of a power law equation for the shear dependence of the viscosity [8]:

$$\acute{\eta} = k' (|\gamma|^{(n-1)})$$

Where, $\acute{\eta}$ is the apparent viscosity, γ is the shear rate and n is the power law index.

The viscosity will also be influenced by the processing history of the material as it passes through the extruder [6]. The tested formulation was processed in a single-screw extruder, from CLEXTRAL; model BC 72 EXTRUDER *(www.clextral.com),* whose configuration and interchangeable screws are appropriate to produce expanded products. The extrusion parameters were set using three extrusion zones with temperatures of 180°C – 200°C; mixture moisture during processing set at 20%; screw speed set at 177 rpm; feeding rate of 2033g/minute and circular matrix of 3.5mm. The developed extruded snacks cookie byte (10 cm length/5gm) was core filled with a 3gm chocolate cream (Figure-1&2 and Table 1). The processed formulation (Table 2 A and B) was manually collected, submitted to a forced air circulation oven drying and, afterwards, it was stored in air tide container until analyses. In order to characterize some technological performance of the breakfast cookie byte the following analyses were performed: apparent density [5], radial expansion index [6], water absorption and water solubility indexes [7], 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 (Ladco, England) with load cell of 50kg, cylindrical compression device of 2mm and ten repetitions. Rate of expansion value of extruded snakes was calculated using the equations water absorption index and water solubility index.

Water Absorption Index

$$= \frac{Weight\ of\ the\ sadiment}{weight\ of\ the\ dry\ solid}$$

Water Solubility

$$\text{Index} = \frac{Weight\ of\ the\ disolved\ solid}{weight\ of\ the\ dry\ solid}$$

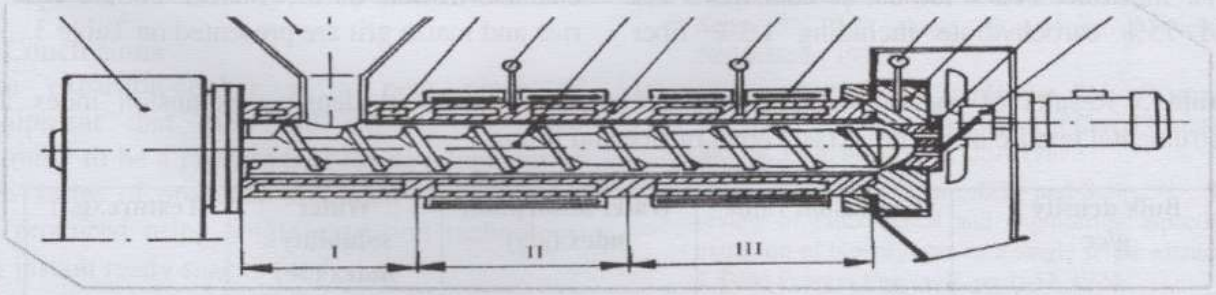

Figure 1 : A cross-section of a single-screw food extruder machine line –Schematic diagram (I.Feed Section , II. Compression Section , III. Metering Section)

Table 2: Operating Information of single extruder Machine

Sl No	Mechanical operating parameters	Range of high shearing extrusion food products
1	Feeding moisture content as wb	20%
2	Max Tem in °c	200
3	L:D	4
4	D:H	8
5	Compression ratio	4:1
6	Screw speed, rpm	177
7	Shearing rate /s	180
8	Mechanical Energy input = Kw-Hr / Kg	0.14
9	Heat transfer through extrusion jacket = Kw-Hr / Kg	0.03

Processing of Cookie Byte are shown in the diagram as bellows:-

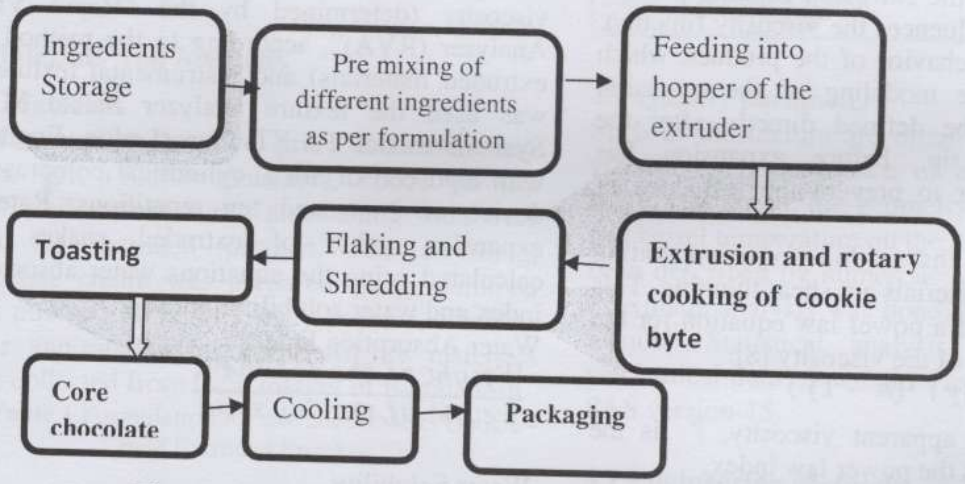

Figure 2 : Flow Chart diagram of Extruded Breakfast production methods

4. Results & Discussions

Proximate analysis of extrusion cookie byte was 2.4% moisture, 11.6% fat, 8% protein, 1.7% ash and 75% carbohydrate including 1.3% fiber respectively. Energy against 100 gm sample was 380 k cal. The results for the technological characterization of the Snacks cookie byte of rice and maize grit are presented on Table 3.

Table 3 Results of means and standard deviation for apparent density, expansion index and instrumental texture of the breakfast cereal of rice and beans

Bulk density g/cc	Expansion value	Water absorption index (g/g)	Water solubility index (%)	Texture (g.f)
0.46±0.00	9.90±0.18	5.41±0.10	64.70±0.14	877.12±120.22

The bulk 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, fat, minerals, protein and starch contents [8,9]. The expansion value is a measure that the prediction of severe or light the extrusion process [2,3]. The extruded cookie byte showed an expansion index of 9.90, whereas a traditional biscuit was 3.5. The extruded sample contained water absorption rate of 5.41g/g and water solubility of 64.70%. This difference can be explained by the different processing zones due to addition of maize grit, which can have contributed to the increase of water solubility of the pre-gelatinized cereal grit mix with sugar and cocoa powder. The cookie byte sample had a hardness value of 877g.f, similar to that verified for snacks of corn flour [8] which varied from 877.12g.f to 997.34g.f.

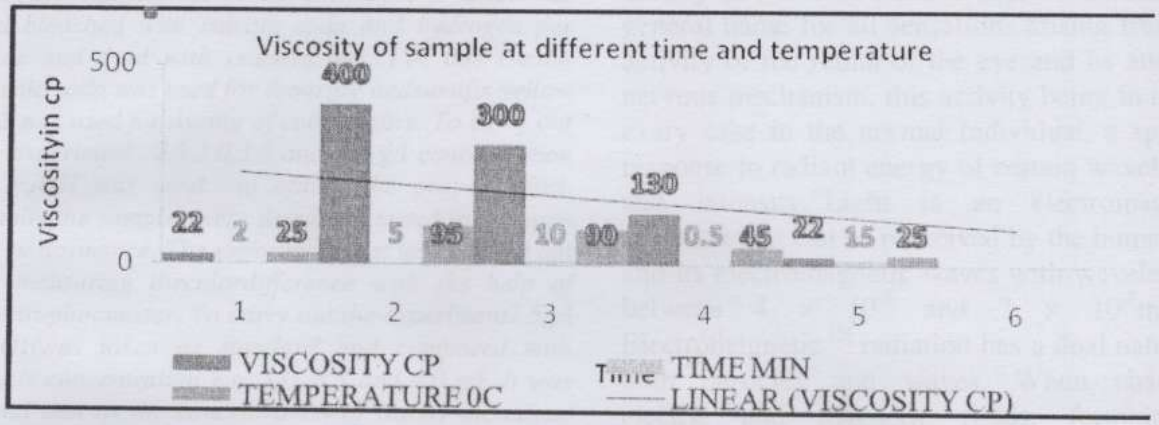

Figure 4 : Result of viscosity at different temperature and time of the extrusion sample

In Figure 4, it is presented the viscosity pattern of the rice and maize cereal cookie byte sample. Severe treatments destroy the starch granular structure, reducing the paste viscosity values below $130c_p$ was observed in this application. Mercier et al. [6] 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.

5. Conclusions

The extrusion-cooker is a new piece of equipment that the field expects the food extruder to be a process tool for development of new series of products. Extruded snacks are to be produced using single extrusion technology for instant ready snacks food.

References

[1] Carvalho, A.V.a, Bassinello P.Z.b, Rios, A. de O (2007), "Processing and technological characterization of extruded breakfast cereal obtained with a mix of broken rice and common bean flour"

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

[3] Anderson, R.A., Conway, H.F., Pfeifer, V.F.; Griffin, L., "Gelatinization of corn grits by roll and extrusion cooking" , Cereal Science Today, v. 14 no. 1, pp. 4-11,1969.

[4] Karwe M.V , " Food Ingredients", v3, Cook College, New Jerchey, USA, 2008.

[5] Van Zuilichem, D.J., "Extrusion Cooking. Craft or Science?" Ph.D. thesis, Wageningen University, Netherlands, 1992.

[6] Mercier, C., Linko, P., and Harper, J.M. , "Extrusion Cooking", American Association of Cereal Chemists, Inc., St. Paul, Minnesota, USA,1989.

[7] Bruin, S., van Zuilichem, D.J., and Stolp, W. , " A review of fundamental and engineering aspects of extrusion of biopolymers in a single screw extruder" J. Food Process Eng., v. 2, pp.1–37, 1978.

[8] Mo_scicki, L., " Effect of screw configuration on quality and SME value of corn extrudate", Teka Commission of Motorization Power Industry in Agriculture, vol. III, pp. 182–186,2003.

[9] van Zuilichem, D.J., Lamers, G., and Stolp, W. , " Influence of process variables on quality of extruded maize grits" Proceedings of the 6th European Symposium on Engineering and Food Quality, Cambridge,1975.

[10] Rosse, J.L. and Miller, R.C. , "Food extrusion. Food Technol", v. 27 , no. 8,pp. 46–53,1973.

[11] Proximate Analysis of snacks food . J. AOAC ,2009.

Acknowledgement

Cookie Byte snacks sample was developed at the Industry of AHZ Agro Industries Pvt Ltd. Gazipur , Bangladesh . Cost of the product sampling was beard by authority of AHZ group. We are grateful for this research funding of the authority.