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Study and Development of Barnyard Millet Based Ready to Eat Product

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A B S T R A C T

A study was undertaken to develop an extruded product using three composite formulation of barnyard millet (BM) and maize (M) grits (180 micron). The formulations (BM: M - 70:30, 60:40 and 50:50) were extruded using a twin screw extruder. Among the three formulations, the 50:50 was reported to be best based on the sensory evaluation. The temperature range of 100-120°C for barrel and 350-400 rpm for screw speed were considered. Based on expansion ratio at lower screw speeds of 400 rpm, the expansion ratio of products was higher especially for barrel temperature of 110°C. However, good expanded products (Expansion ratio - 3.949) could be obtained also at optimum screw speed and barrel temperature.

Introduction

Barnyard millet is the fastest growing millet and its originated in eastern India. As every kind of millet, barnyard millet is also an appropriate food for patients intolerant to gluten which causes celiac disease. Seeds of this crop are nutritious. It can produce ripe grain in 45 days from the sowing time under the optimal weather conditions. Small seeds of barnyard millet are processed on groats that are used for preparation of different types of porridges. These days various Ready-to-eat processed cereal grain formulations are made which are suitable for human consumption without further cooking. These are made primarily from maize, wheat, oats or rice, usually with added flavor and fortifying ingredients (Fast, 1993). Puffed cereals are commonly used as ready-to eat breakfast foods or as ingredients in snack formulations.

Extrusion cooking of millets appears to be highly promising in the preparation of value added traditional and novel food products with good keeping quality. It is an emerging food processing technology in India. A variety of *ready-to-eat* traditional snacks, breakfast cereals and supplementary foods could be prepared by extrusion cooking technology. However, hardly any commercial product based on small millets is found on the

shelf. Extruded products are crispy and crunchy in texture similar to the deep oil fried products but, contain only 2-3 % fat. Extrusion technology can be successfully used for the preparation of many value added products.

Materials and Methods

The barnyard millet was processed (dehusked) using a Domestic Burr Mill (make: Ashirwad Co., Ahmedabad) subsequently polished in a friction type Rice Polisher (make: Bhavani Industries, Srirangapatna, Karnataka) to get millet rice grains. A domestic grain pulverizer (Plate 1) was used to mill different millet rice grains into suitable flours/grits, which was later sieved using BS-18 mesh 180micron) screen.

Formulation and preparation of samples

After several trials blending barnyard millet grits with maize grits (BS 18 mesh size) in different formulations (Table 1) were followed to get the best blending effect trials were conducted at optimized extruder operated conditions (Screw speed -350 rpm; Heater no.1-110^{o}C, Heater no.2 -50^{o}C).based on trial and error method. The barnyard millet and Maize grits were thoroughly blended and 90ml of water per kg of blend was added to bring its moisture content to about 18-20%. The material was equilibrated for about 30 minutes before extrusion

Operating procedure of extruder

The extruder was primed for actual operation half-an-hour before. After fixing the required 'die', (3 mm circular hole) the main switch was put on. The Heater no.1 was set at 110^{o}C and Heater no.2 was set at 50^{o}C and both were switched on for barrel heating. Cooling water line to solenoid valve is shut till required temperature was reached. The other operational settings namely, screw speed (350 rpm), feeder speed (42% of max) and cutter (36% of max) were set in the main control panel.

Recipe and procedure for preparation of barnyard millet extruded type masala

Since the extrudates from the twin screw extruder were bland in taste, they were applied with sweet – sour-spicy mix before serving to sensory panel by following the procedure: Fry extrudates in 3 tsp of sunflower oil (per 100 g) and add 2 tsp of *spicy mix* as a flavoring agent (*Chata masala* supplied by M/s Sonram Company, Doddbalapur, Bangalore

Sensory Evaluation of Fry extruded type Products

The prepared products were evaluated for sensory characteristics using nine point hedonic scale method (Ranganna, 1997) by a panel of 10 trained judges along with the commercially available product as a control. Among the three formulations tried, one best *extruded* product based on good colour, texture, flavour, taste, crispness and overall acceptability, which was used for further studies to optimize the operating parameters of the Twin Screw Extruder.

Optimization of twin screw extruder operating parameters for barnyard millet based ready-to-eat products

The operating parameters of the twin screw extruder mainly, the barrel temperature and the screw speed, were optimized for the various 'best selected' barnyard millet – maize based extruded products. Three barrel temperatures and three screw speeds were selected in factorial combinations to produce extrudates from the already finalized barnyard millet: Maize Grit combinations. The extrudates were analyzed for physical parameters like expansion ratio, water

absorption index, water solubility index, true density, bulk density, etc. Based on the extrudate characteristics (mainly high expansion ratio), the optimum screw speed and barrel temperature were selected.

Expansion ratio

The ratio of diameter of extrudate to the diameter of 'die' was used to express the degree of expansion of extrudates (Fan *et al.*, 1996). The diameter of extrudate was determined as the mean of 10 random measurements made with a vernier caliper. The extrudates expansion ratio was then calculated as Table 2:

$$Expansion\ ratio(m/m) = \frac{Extrudate\ Diameter\ (m)}{Die\ Diameter\ (m)} \quad \text{.....(1)}$$

Water Absorption Index (WAI) and Water Solubility Index (WSI)

WAI and WSI were determined by the method described by Anderson (1982). The extruded puffs were milled to a mean particle size of 200-250 µm. About 2.5 g of sample was dispersed in 25 ml distilled water and a glass rod was used to break up any lumps. The sample was stirred for 30 min. The dispersion were rinsed into a tarred centrifuged tube, made up to 32.5 g and centrifuged at 4000 rpm-g for 15 min. The supernatant was decanted for determination of its solid content and sediment was weighed. WAI and WSI were calculated as:

$$\text{Water Absorption Index (WAI)} = \frac{\text{Weight of wet sediment (g)}}{\text{Intial Weight of dry solids taken (g)}} \quad \text{.....2}$$

$$\text{Water Solubility Index (WSI)} = \frac{\text{Weight of dissolved solids in supernatant (g)}}{\text{Weight of dry solids (g)}} \times 10 \quad \text{.....(3)}$$

True density

True density of extruded barnyard millet – maize based extruded products was determined as per the method suggested by Deshpande and Poshadri (2011). A known weight (1 g) of extrudate was powdered and the ground sample was poured into a burette containing toluene. The rise in volume in the burette was noted as the true volume of the sample. Then the true density was calculated as:

$$\text{True density (kg/m}^3\text{)} = \frac{\text{Weight of ground sample of extrudate (kg)}}{\text{Rise of toulene level (m}^3\text{)}} \quad \text{...4}$$

Individual extrudate density

The average sample diameter (d) and length (L) of 25 extrudates were determined using a vernier caliper (least count 0.02 mm) assuming the extrudates as cylinder (Launay *and* Lisch., 1983). The volume of each sample was computed as ($\pi d^2 L/4$). By measuring the mass of each extrudate, the value of bulk density of individual extrudate was computed as below. The mean of 25 readings was recorded as bulk density.

$$\text{Bulk density(kg/m}^3\text{)} = \frac{\text{Mass of extrudates (kg)}}{\text{Volume of extrudates (m}^3\text{)}} \quad \text{..5}$$

Results and Discussion

Sensory characteristics of barnyard millet based *extruded products* products

Colour

The mean sensory scores for colour of barnyard millet based extrudates ranged from 7.42 to 7.74 and the control product scored 8.46. There was no significant difference between extrudates from mixes and control. The highest colour score was recorded for control followed by Bc_1 and Bc_2 (Table 3).

Texture

The mean texture scores of barnyard millet

based extrudates ranged from 7.24 to 8.04 and there was no significant different between the products from formulated mixes and control. The highest score was however recorded by the control (8.40) and the lowest score was for the product of Bc_3 formulation. The products of Bc_1, Bc_2 and Bc_3 were on par with the control as far as the texture was concerned (Table 3).

Flavour

The sensory score for flavour of barnyard millet based extrudates varied from 7.16 to 7.72 and were on par with the flavor score for the control sample. The highest score was obtained by commercial product (8.54) followed by Bc_1.

Taste

The mean sensory taste scores ranged from 6.96 to 8.02 and the highest score was recorded with control followed by products of Bc_1 and Bc_2 formulations (Table 3).

There was a significant difference between the barnyard millet based extrudates and the control. However, the product of Bc_1 was on par with the control.

Crispness

With regard to crispness, there was a significant difference between the barnyard millet based products and control. The mean sensory scores of developed products ranged from 6.88 to 7.78. The highest score was recorded with control (8.28) and it is on par with treatments Bc_1 and Bc_2 (Table 3).

Overall acceptability

The mean sensory scores of barnyard millet extrudates ranged from 6.92 to 7.96 (Table 3). The highest score for overall acceptability (8.41) was recorded for the control sample. With an acceptability score of 7.96, the product of formulation Bc_1 was reckoned to be on par with commercial control product.

Selection of best product through sensory evaluation

Sensory evaluation of barnyard millets based *ready-to-eat* expanded products has showed that (Plate 2), barnyard millet, maize grits combinations (Table 3) was to be the best due to its bitter taste in barnyard millet, for further studies and factorial experimental combinations of three screw speeds (350, 400 & 450 rpm) and barrel temperatures (100,110 and 120 °C) were selected and the resultant products were analyzed for the physical parameters namely, expansion ratio, water solubility index, water absorption index, true density and bulk density.

Expansion ratio

The effect of twin screw extruder operating parameters namely, barrel temperature and screw speed on the expansion ratio of barnyard millet – maize based extruded products was observed (Fig. 1). It was observed that at screw speed of 400 rpm (s_2), the expansion ratio of products was higher especially for barrel temperature of 100ºC (t_1). However, good expanded products (Expansion ratio- 3.675) could be obtained with higher screw speed of 450 rpm (s_3) at 120ºC (t_3) barrel temperature.

Based on the experimental trials, it was clear that the maximum expansion ratio of 3.949 could be achieved when the barrel temperature was 100°C (t_1) and screw speed of 450 rpm (s_3), in barnyard millet – maize based formulations. Similar results were reported by Bhattacharya, M. and Hanna, M.A (1987a) for extruded products.

Table.1 Different formulations of barnyard millet based extruded product

Barnyard millet & Code	Barnyard millet Grits (%)	Maize Grits (%)	Moisture Content of Blend (% wb)
Bc_1	50	50	18
Bc_2	60	40	18
Bc_3	70	30	18

Table.2 Optimization of twin screw extruder operating parameters for barnyard millet based ready-to-eat products

Selected Formulation	Independent Variable	
	Barrel Temperature (^{0}C)	Screw Speed (rpm)
Barnyard millet (50%): maize (50%)	100	350
	110	400
	120	450

Table.3 Mean sensory scores of barnyard millet based r*eady-to-eat* hot extruded products

Millet Formulation	Colour		Texture	Flavour	Taste	Crispness	Overall acceptability
Bc_1	7.74		8.04	7.72	8.02	7.78	7.96
Bc_2	7.44		7.66	7.44	7.36	7.50	7.34
Bc_3	7.42		7.24	7.16	6.96	6.88	6.92
Control	8.46		8.40	8.54	8.54	8.28	8.41
GM	7.76		7.83	7.68	7.68	7.99	7.66
F-test	NS		NS	NS	*	*	**
CD@5%	-	-	-	0.97	0.78	0.86	
SEm±	0.28	0.28	0.32	0.32	0.26	0.28	

Bc_1 - Barnyard millet rice grits (50%): Corn grits (50%);
Bc_2 - Barnyard millet rice grits (60%): Corn grits (40%);
Bc_3 - Barnyard millet rice grits (70%): Corn grits (30%);
NS - Non significant; * - Significant at 5 %; ** - Highly Significan

Plate.1 Primary processing machineries

Plate.2 Sensory Evaluation of *Ready-to-eat expand* extruded Products

Fig.1 Effect of twin screw extruder operating parameters on Expansion Ratio of barnyard millet based ready-to-eat extruded products

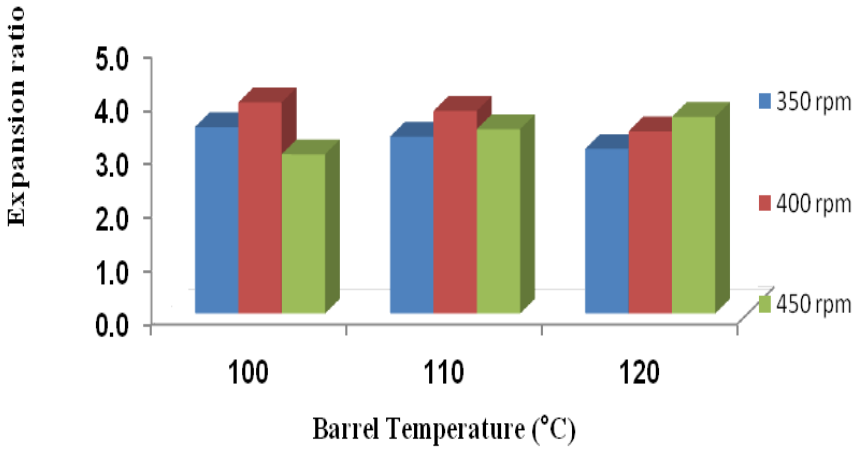


Fig.2 Effect of twin screw extruder operating parameters on WAI of barnyard millet based ready-to-eat extruded products

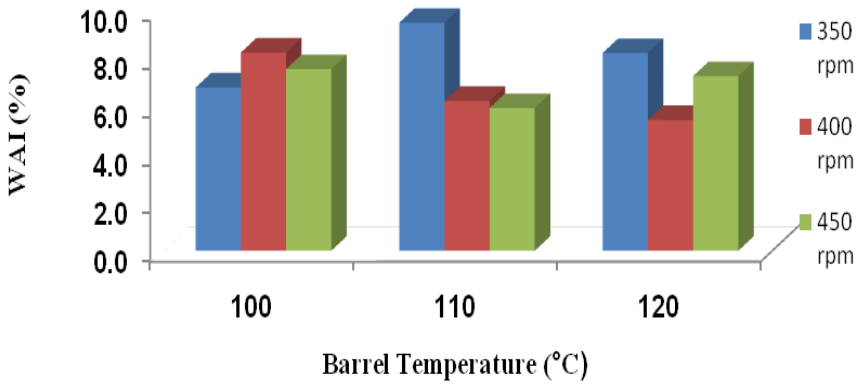


Fig.3 Effect of twin screw extruder operating parameters on WSI of barnyard millet based ready-to-eat extruded products

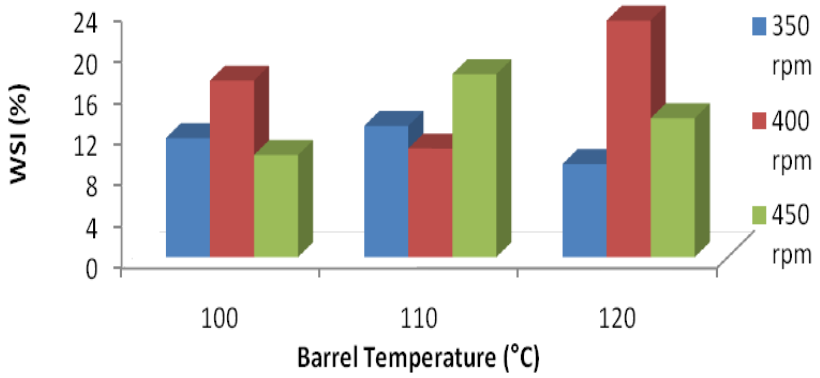


Fig.4 Effect of twin screw extruder operating parameters on True density of barnyard millet based ready-to-eat extruded products

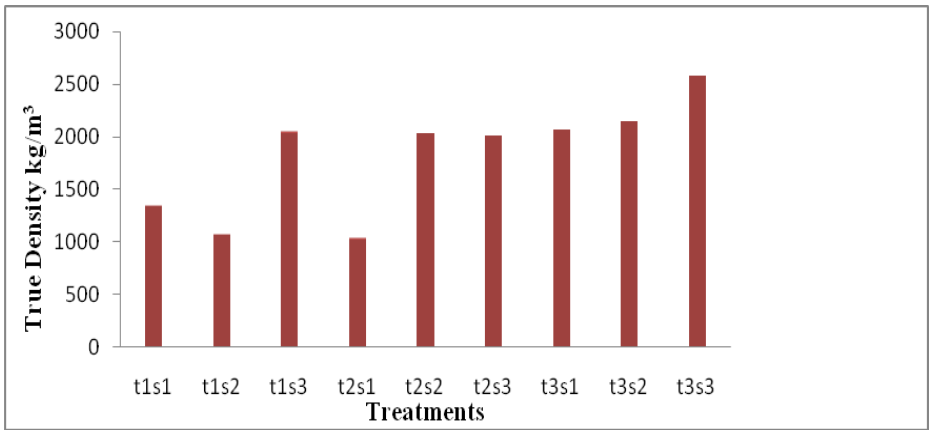
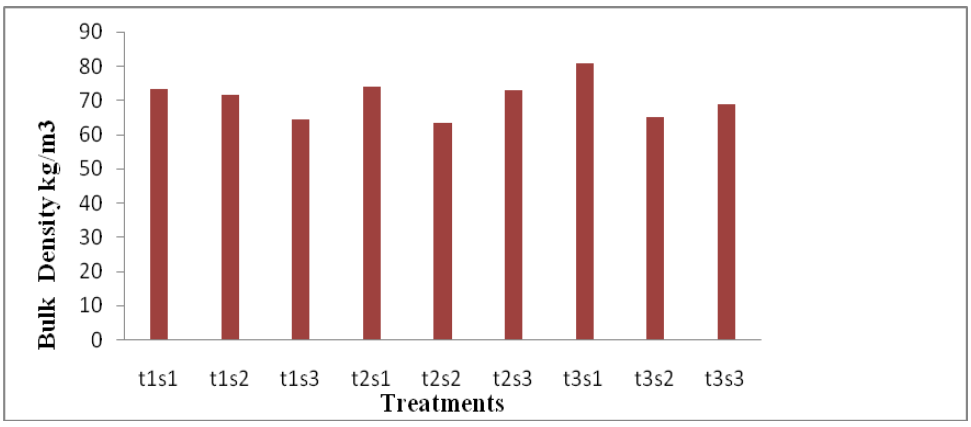


Fig.5 Effect of twin screw extruder operating parameters on Bulk density of barnyard millet based ready-to-eat extruded products



Water absorption index

The Water Absorption Index of barnyard millet based products (Fig. 2) ranged from 5.420 to 9.445. The highest value of WAI was recorded in t_2s_1 combination and the lowest was recorded in t_3s_2. Similar results were recorded by Williams (1977). The research was oriented towards the development of low water absorption index product which was succeeded in the present study that helps in maintenance of more air pockets in the product which is desirable extruded materials.

Water Solubility Index (WSI)

The Water Absorption Index of barnyard millet based products (Fig. 3) ranged 9.0565 to 23.0260. The highest value of WSI was recorded in t_3s_2 combination and the lowest value was recorded in t3s1. WSI data indicated that both the barrel temperature and screw speed showed highly significant effect on WSI of barnyard millet based products.

In the present study, the extrudates from small millets showed high WSI which was due to high degree of gelatinization achieved during extrusion cooking. However, the variation in WSI was understandable since the processing temperature (barrel) and the screw speed varied for different products. These findings are supported by the findings of Anderson *et al.*, (1969), Badrie and Mellows (1991) and Tang and Ding (1994).

True density and Bulk density

The effect of twin screw extruder screw speed on the true and bulk density of barnyard millets based products (Fig. 4 and 5) indicated that, for different screw speed and temperature, true density of products varied considerably from 1029 – 2580 kg/m^3. Similarly, the bulk density of extruded *type* products for different screw speed varied from 64.30 – 80.87 kg/m^3 for barnyard millet. Similar results were found by Thymi *et al.*, (2005) and Harmann and Harper (1973).

In conclusion the study clearly revealed that preparation of extruded products using combination 50:50 (Bc_1) of barnyard millet and maize grits under a good hygienic environment improved the product acceptability as compared to commercially available samples (control). The best quality as per the lower water absorption index value and highest expansion ratio, water solubility index, bulk density and true density was observed in the product developed under the extruder barrel temperature and screw speed of 120ºC and 400 and 450 rpm.

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