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Effect of pre-treatment on puffing of finger millet, bengal gram and maize and their flours

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■ **ABSTRACT :** The effect of pretreatments on puffing of finger millet, bengal gram and maize were studied. The grains were pre – treated with water and citric acid solution (1% concentration). The puffed grains were evaluated for puffing yield, bulk density and angle of repose. All these three parameters of the puffed grains pre-treated with water. The yield (%) of corn varied to an higher extent for about 16 per cent for puffed grains pre-treated with water than pre-treated citric acid. There was almost no effect of pre-treatments of bengal gram on the puffing of grains. The bulk density of citric acid pre-treated corn was found to be 0.659 g/cc that is less than bulk density of water pre-treated corn puffed corn. The angle of repose of bengal gram that is pre-treated with water was 32.43^0 and that of citric acid pre-treated was found to be 31.51^0. The sensory evaluation of the chapatti was made with blend of the three flours of puffed finger millet, bengal gram and maize with wheat in different proportions. The chapatti made from the blend of wheat 80 per cent maize 10 per cent finger millet 5 per cent and bengal gram 5 per cent has good overall acceptability of 8.34 on ten point hedonic scale by sensory evaluation.

■ **KEY WORDS :** Puffing, Maize, Finger millet, Bengal gram

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Maize (*Zea mays* L.) is also known as corn, is the world's third most important cereal crop after wheat and rice. It has very high yield potential and is commonly known as queen of cereals.

Maize contains about 10 per cent proteins, 4 per cent oil, 70 per cent carbohydrates, 2.3 per cent crude fibre, 10.4 per cent albuminoides and 1.4 per cent ash. Maize has significant quantities of vitamin A, nicotinic acid, riboflavin and vitamin E. World produces about 856 million tons of maize, whereas India produces about 21.76 million tons (2011-12), (*www.indiastat.com*). It is grown over an area of 8.33 lakh hectares in Andhra Pradesh with total production of 36.58 lakh tones (*www.indiastat.com*). Bengal gram (*Cicer aritinum* L.) is also called chick pea or gram in south Asia and garbanzo bean in most of the developing countries in the world. India is the major producer of bengal gram in the world, accounting for 61.65 per cent of the total world area under bengal gram and 68.13 per cent of the total world production (Anonymous, 2010). The area in the country was 8.25 million hectares with productivity of 855 kg ha^{-1} 2008-2009. The important growing states of bengal gram in India are Madhya Pradesh, Uttar Pradesh, Andhra Pradesh and Karnataka. Finger millet (*Eleusine coracana*) is a good source of calcium and iron in the range of 220 - 450 and 3 to 20 mg/ 100 g, respectively, lipids 1.5 and proteins 7 per cent Ca, Fe contents of finger millet are higher than mg per cent. The flour of finger millet is widely used in India for

making dumpling (gelantinized dough ball) and roti. Finger millet flours are mostly used in preparation of traditional dishes like spiced and sweetened millet mix, roti mix sweet and functional cookies etc. Best possible way of utilization of this flour could be by blend with wheat flour in different proportions.

Traditionally puffing of finger millets has been used for ages and used as ready to eat foods. Puffing of bengal gram is extensively practiced in India particularly in south. Puffing improves flavour, modifies texture and helps in dry and wet grinding of bengal gram. Puffing grain mixed with oil seeds or popped cereals and spiced or sweetened are popular snack food. Studies have shown that moisture conditioning prior to heating helps in good puffing, steaming; parboiling operations does not show any effect on puffing.

Finger millet, bengal gram and maize grains are hard and cannot be grounded finely. As a result, the flour obtained from these grains lacks glutinous material. The dough, therefore, is easily disrupted during handling and difficult to roll into a good chapatti. The coarser outer husk is reported to be responsible for the poor acceptability of these grains. Hence, grain treatments with water, lime or buttermilk are preferred for preparation of flour.

India is far behind in the finger millet, bengal gram and maize based industries. These grains are used as a food grain and also in agricultural and industrial sectors like livestock, poultry and animal feed, starch and starch based products. Presently, there is a demand for finger millet, bengal gram and maize for production of value added products.

Puffed flour based products are mostly used by the population at higher attitudes and for school children. Puffed grain flour improves digestibility. There is less reported literature on characteristics of puffed flours. The present paper gives the information on comparison of physical properties of putted finger millet, bengal gram and maize with raw finger millet, bengal gram and maize. And also, gives sensory evaluation of chapatti made with blending three puffed flours of finger millet, bengal gram and maize.

Fresh maize cob of 100g has moisture 88g protein 1.90g,carbohydrate 4.0g,fat 0.2g,calories 30kcal, fibre 2.41g,ash 46g,total sugars 415mg,thiamine 0.06mg, calcium and Iron 1.97mg (Anitha and Rajyalakshmi, 2005). Finger millet based mixes had calcium and Iron contents of 35 to 330mg per cent and 1.2 to 9.6mg per cent, respectively. The continuous use of finger millet based foods improves ca and hemoglobin levels in children Premavalli *et al.* (2006). Water, butter milk and citric acid solutions were used for pretreatments in the preparation of puffing finger millet. The changes with pre-treatment were predominant with respect to physical characteristics while the chemical characteristics not significantly affected. Water and butter milk pretreatment influences puffing yield and bulk density (Premavalli *et al.*, 2005).

Step by step puffing of Bengal gram has been given as :

- Initial moisture content should be around 7.8 per cent;
- Preliminary roasting of grains with sand at 170 c for 75 sec;
- Tempering the grains for about 90 min to reach a m.c of about 4.9 per cent;
- Dipping in water for 5sec to absorb 0.8 per cent additional moisture force;
- Final puffing of roasting at 230 c for 30 sec;
- Applying impact between a roller and a hot plate for dehusking and splitting;
- Bulk volume of grains get doubled by puffing.

METHODOLOGY

Raw and puffed grains (finger millet, bengal gram, maize) are subjected to determination of physical properties such as bulk density, thousand grain weight and yield percentage.

The moisture content on wet basis of the dried grain were determined by hot air oven method for finger millet, bengal gram and maize, this was done by putting 10-15 g of grains at 130°C for 1h for each variety into two containers and then weighed using weight balance. The average moisture content of the two samples was calculated to obtain the moisture content of the samples using the relationship below (Chen, 2003).

$$\text{MC (w.b)}\,\% = \frac{W_W - W_d}{W_W} \times 100$$

where, W_w = weight of wet grains, g

W_d = weight of dried sample, g

The average bulk density of the maize samples were determined by using the standard test weight procedure by filling a container of 1000 ml with samples of 100 ml

by tapping twice for uniform packing and to minimize wall effect and then weighed the contents (Singh and Goswami, 1996).

Angle of repose (Φ) of the maize, finger millet and Bengal gram grains was calculated from the height and diameter of the naturally formed heap of the grains on a circular plate (Akaaimo and Raji, 2006 and Jha *et al.*, 1999).

Yield percentage of puffed grains was calculated by talking the weight of puffed grains expressed as percentage of initial weight.

Maize, bengal gram and finger millet (11.73% m.c)

↓

Conditioning (19% M.C)

↓

Equilibration for 2 hours

↓

Roasting in sand at 270^{0}C

↓

Pretreatment with water and citric acid (1% concentration) for 2 hours

↓

Roasting upto 19% M.C in hot pan (260 - 270^{0}C)

Fig. A: Puffing of maize, bengal gram and finger millet

RESULTS AND DISCUSSION

The findings of the present study as well as relevant discussion have been presented under following heads:

Effect of pre-treatments on bulk density :

The bulk density raw corn was 831.93kg/m^3 and the bulk densities of the water and citric acid pre-treated samples were 72.28 kg/m^3 and 65.97 kg/m^3.The bulk density of the samples, which were treated with citric acid was 8.726 per cent less than that of water pre-treated samples.

The bulk density of bengal gram was 814 kg/m^3.The bulk densities of water and citric acid pre-treated samples were 485 kg/m^3 and 460 kg/m^3. There was a slight difference between the two bulk densities of puffed samples.

The initial bulk density of finger millet is 813 kg/m^3. The bulk densities of the water and citric acid pre-treated samples were 190 kg/m^3 and 173 kg/m^3, respectively. The average bulk density of the samples which were treated with citric acid was found to be 8.94 per cent less than that of the water pre-treated samples (Tables 1 and 2).

Effect of pre-treatments on yield (%) :

The yield percentage of corn, which was pre-treated with water was high (81.84%) compared to the corn that is pre-treated with citric and (65.86%). The difference between the yield percentage of corn, which were pre-treated with water and citric acid was around 16 per cent pre-treatment with citric acid solution left lot of grains in unpuffend stage. The puffing yield percentage of bengal gram which was pre-treated with water was higher (94.90%) than that of citric acid pre-treatment (91.86%). The average yield (%) of putted finger millet. which was pre-treated with water was higher (90.34%) than citric acid pre-treated sample (85.56%). The difference of yield percentages of water and citric acid pre-treatment samples was 4.78 per cent (Table 3).

Effect of pre-treatment on angle of repose :

The angle of respose of the raw corn was 30.76^0 and angle of repose of corn pre-treated with water was higher (38.02^0) than citric acid (36.90^0). Similarly trend was observed in case of bengal gram as in the case of yield (%) and bulk densities of the puffed samples. The water pre-treated, puffed bengal gram has higher angle of respose (32.43^0) than citric acid solution (31.51^0).The average angle of respose of raw bengal gram was

Table 1 : Bulk density of raw maize, bengal gram and finger millet

Sr. No.	Volume(ml)	Weight of raw material			Bulk density		
		Maize	Bengal gram	Finger millet	Maize	Bengal gram	Finger millet
1.	1000	826.5	814.3	810.6	0.826	0.814	0.810
2.	1000	834.3	811.6	819.3	0.834	0.812	0.819
3.	1000	833.7	816.5	811.7	0.833	0.816	0.811
Average					0.831	0.814	0.813

Table 2 : Effect of pre - treatments on bulk density of raw maize, bengal gram and finger millet

Weight of puffed material, which is pre treated with		Bulk density of puffed material, which is pretreated with	
Maize			
Water	Citric acid solution (g)	Water (g/cc)	Citric acid solution (g/cc)
75.5	65.8	0.0750	0.0658
65.8	68.6	0.0658	0.0686
75.9	63.4	0.0759	0.0634
Average bulk density (g/cc)		0.0722	0.0659
Bengal gram			
491	455.6	0.491	0.456
478.7	460.4	0.479	0.460
483.9	465.3	0.484	0.465
Average bulk density (g/cc)		0.485	0.460
Finger millet			
193	178.3	0.193	0.178
187.8	175.5	0.187	0.175
190.6	168.2	0.190	0.168
Average bulk density (g/cc)		0.190	0.173

Table 3 : Effect of pre-treatments on yield (%)

Sr. No.	Initial weight of raw corn before puffing (g)	Weight of puffed corn, which is pre treated with		Yield of puffed corn, which is pretreated with	
		Water	Citric acid solution (g)	Water (g/cc)	Citric acid solution (g/cc)
Maize					
1.	250	205.6	170.6	82.24	68.24
2.	250	200.4	159.6	80.16	63.84
3.	250	207.8	163.8	83.12	65.52
Average yield percentage				81.84	65.86
Bengal gram					
1.	250	239	226	95.60	90.40
2.	250	237	230	94.80	92.00
3.	250	236	233	94.40	93.20
Average yield percentage				94.90	91.86
Finger millet					
1.	250	227.5	212.6	91.00	85.04
2.	250	229	219.7	91.60	87.88
3.	250	223.6	209.4	89.44	83.76
Average yield percentage				90.34	85.56

Table 4 : Effect of pretreatments on angle of repose for raw corn, bengal gram and finger millet

Sr. No.	Diameter of the platform, cm	Height of the cone of raw corn above the platform, cm			Angle of repose, ^{0}		
		Maize	Bengal gram	Finger millet	Maize	Bengal gram	Finger millet
1.	15	4.4	4.5	3.9	30.39	30.96	27.47
2.	15	4.6	4.4	3.8	31.52	30.39	26.86
3.	15	4.4	4.4	4.0	30.39	30.39	28.07
Average					30.76	30.58	27.46

30.58^0.The angle of respose of the raw finger millet was found to be 27.46 per cent for the samples which were pre-treated with water and citric acid solutions were found to be 32.42 and 31.33, respectively (Tables 4 and 5).

Comparison of puffed maize bengal gram and finger millet :

The bulk density, angle of repose and yield percentage of the citric acid pretreated puffed grains was less than that of the water pre-treated puffed grains (From the Fig. 1, 2 and 3). The bulk densities of raw finger millet, bengal gram and maize were almost equal. The bulk density of puffed bengal gram was more when compared to puffed finger millet and corn (Fig. 1). The angle of repose of puffed grains (water pre-treated) was more compared to citric acid pre-treated puffed grains (Fig. 2). The angle of repose of puffed corn (water pre-treated) was observed to be high (38.02^o) among these three grains. The yield percentage of the bengal gram was more when compared to finger millet

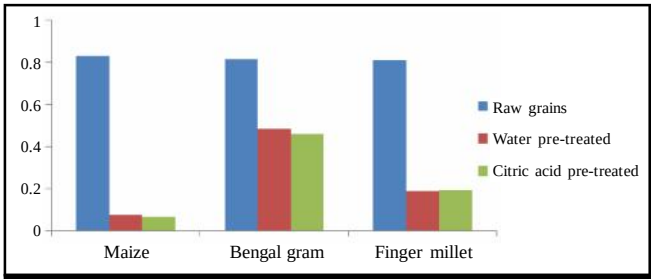

Fig. 1 : Comparison of bulk density of raw grains and different pre-treated puffed grains

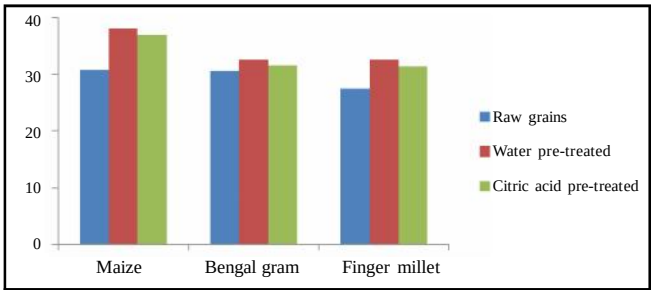

Fig. 2 : Comparison of angle of repose of raw grains and different pre-treated puffed grains

Table 5 : Effect of pretreatments on angle of repose for puffed maize, bengal gram and finger millet

Height of the cone which is pretreated with		Angle of repose, ^{0}	
Maize			
Water, cm	Citric acid, cm	Water	Citric acid
5.7	5.7	37.23	37.23
5.9	5.5	38.19	36.25
6.0	5.7	38.66	37.23
Average angle of repose		38.02	36.90
Bengal gram			
4.6	4.7	31.52	32.07
4.9	4.7	33.15	32.07
4.8	4.4	32.62	30.39
Average angle of repose		32.43	31.51
Finger millet			
4.8	4.6	32.61	31.52
4.9	4.5	33.15	30.96
4.6	4.6	31.52	31.52
Average angle of repose		32.42	31.33

Table 6 : Sensory evaluation of the blend of the three flours of puffed grains with wheat on different proportions

Sample	Colour	Appearance	Flavour	Texture	Chewability	Overall acceptability
Sample – I	8.25	8.25	7.84	8.06	7.84	8.34
Sample – II	7.28	7.18	7.71	7.15	7.25	6.97
Sample – III	7.5	7.21	7.71	6.96	7.43	7.48

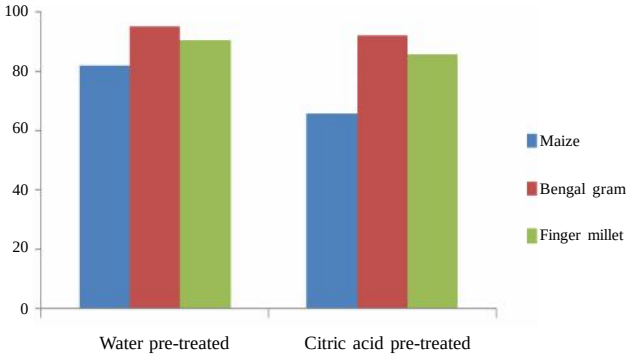

Fig. 3 : Comparison of yield of raw grains and different pre-treated puffed grains

and corn (Fig. 3). The yield percentage of citric acid pre-treated puffed corn is less than water pre-treated by around 16 per cent. The remaining yield percentage is nearly equal.

Sensory evaluation :

The sensory evaluation of the chapatti made with the blend of the three flours of puffed finger millet, bengal gram and maize with wheat in different proportions as given below:

Sample-I :

Wheat – 80 per cent, maize – 10 per cent, finger millet – 5 per cent, bengal gram – 5 per cent.

Sample-II :

Wheat – 70 per cent, maize – 10 per cent, finger millet – 10 per cent, bengal gram – 10 per cent.

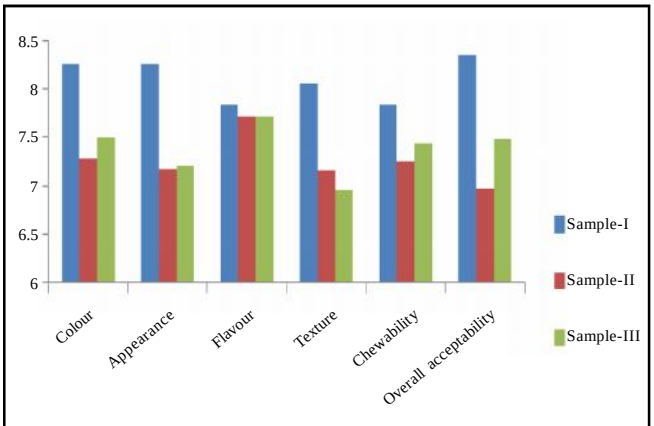

Fig. 4 : Sensory evaluation of three samples

Sample-III :

Wheat – 75 per cent, maize – 10 per cent, finger millet – 10 per cent, bengal gram – 5 per cent.

From the data (Tables 4 and 6) obtained from the sensory evaluation the chapatti made from the blend mix of wheat-80 per cent, maize-10 per cent, finger millet-5 per cent, bengal gram-5 per cent has good overall acceptability of 8.34 on ten point scale and the mix of wheat-75 per cent, maize-10 per cent, finger millet-10 per cent, bengal gram-5 per cent has the overall acceptability of 7.48 on ten point scale and the chapatti having the proportions of wheat-75 per cent, maize-10 per cent, finger millet-10 per cent, bengal gram-5 per cent has least overall acceptability of 6.97 on ten point scale.

Conclusion :

The bulk density of the corn which were treated with citric acid (0.0659 g/cc) was 8.73 per cent less than that of the water pre-treated samples (0.0722 g/cc). The yield percentage of the corn pre-treated with water (81.84%) was high compared to that of the corn pre-treated with citric acid (65.86%). The angle of repose of corn that is pre-treated with water (38.02°) and citric acid solution (36.90°) were found to be nearly equal. The bulk densities of the water citric acid pre-treated bengal gram were nearly equal and they were 0.485 per cent g/cc and 0.460 g/cc, respectively. The yield percentage of the bengal gram pre-treated with water (94.90%) was less than that of the bengal gram pre-treated with lime (91.86%). The angle of repose of bengal gram which was pre-treated with water (32.43°) and citric acid solution (31.51°) were found to be nearly equal. The bulk density of the ragi, which was pre-treated with citric acid (0.173 g/cc) was 8.94 per cent less than that of the water pre-treated samples (0.190 g/cc). The yield percentage of the ragi, which was pre-treated with water (90.34%) was high compared to that of the corn pre-treated with lime (85.56%). The angle of repose of *Ragi*, which was pre-treated with water and citric acid solution were found to be 32.42° and 31.33°, respectively. From the data obtained from the sensory evaluation the chapatti made from the blend mix of wheat-80 per cent, maize-10 per cent ragi-5 per cent, bengal gram-5 per cent had good overall acceptability of 8.34 on ten point scale.

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