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Nilza Othzes
Ph.D. Research Scholar, Department of Agricultural Process Engineering, College of Agricultural Engineering and Technology, Parbhani, Maharashtra, India

Smita Khodke
Head, Department of Agricultural Process Engineering, College of Agricultural Engineering and Technology, Parbhani, Maharashtra, India

Madhuri Gajabe
Ph.D. Research Scholar, Department of Agricultural Process Engineering, College of Agricultural Engineering and Technology, Parbhani, Maharashtra, India

Corresponding Author:
Nilza Othzes
Ph.D. Research Scholar, Department of Agricultural Process Engineering, College of Agricultural Engineering and Technology, Parbhani, Maharashtra, India

Identification of variety of soybean for the production of quality puffed soynuts

Nilza Othzes, Smita Khodke and Madhuri Gajabe

Abstract
Soynuts are becoming popular ready-to-eat (RTE) snacks nowadays. In the present investigation efforts were made to identify the varieties of soybean for the production of quality puffed soynuts. Puffed soynuts were prepared from four different varieties of soybeans *viz*. MAUS-612, MAUS-621, MAUS-158 and JS-335 respectively. Raw soybean was soaked in water at 180 °C temperature for 3 min, followed by surface drying for 3 h and then puffing was carried out at 180 °C temperature in electrically operated roaster which works on the principle of high temperature short time (HTST). Raw soybean and puffed were then evaluated for its physical properties, textural characteristics, color and Organoleptic properties. Size of soybean variety MAUS-612 was found maximum as compare to other varieties. Soybean variety of MAUS-612 also found better in terms of color, texture and sensory qualities. Soybean variety of MAUS-612 was found suitable for production of quality puffed soynuts.

Keywords: Soybean varieties, color, texture, sensory evaluation

Introduction
Soybean (*Glycine max*) is having unique chemical composition place this food as one of the most economical and valuable agricultural commodity. Soybean contains highest protein content (40%), of lipids (19.9%), carbohydrates (35%) and (17-24%) oil (USDA, 2021) [19]. In spite of the nutritional significance of soybean, it also contains a large number of biologically active anti-nutrients like protease inhibitors, oligosaccharides, phytates, saponins, lectins and glucosinolates (Liener 1976 and Rackis 1974) [15]. Thermal treatment such as boiling, soaking, steaming, autoclaving, roasting and puffing are used for inactivating these anti-nutrients. (Liu, 1997) [11]. Consumption of soy products is reported to be beneficial to prevent kidney disease, heart disease, diabetics, obesity, blood cholesterol and cancer. (Bolla, 2015) [3].
It has good balance of the essential amino acids making it a good supplement for cereals that can be used to improve the diet of millions of people, especially the poor and low income earners in developing countries because it produces the greatest amount of protein used as food by man. (Liu, 1997) [11].
Puffing of soybean consist of hydrothermal treatment as it involves the release or expansion of vapor inside the grains, while it is subjected to intensive heating for a short time. Puffing has been also used to deactivate anti nutritional components in soybeans and to give characteristic flavor, color and enhance nutrients, mineral availability to final products of puffed soynuts. Thus, consumption of puffed soynuts provides all the nutrients available in whole soybean. Therefore, for identification of suitable variety of soybean, the physical properties, texture characteristics, color and Organoleptic properties of raw soybean and puffed soynuts from four different varieties were analyzed.

Material and Methods
Preparation of soy nuts
Four different varieties of soybean *viz*. MAUS-612, MAUS-621, MAUS-158 and JS- 335 were procured from Seed Processing Center, VNMKV, Parbhani, Maharashtra and all experiments were performed in Department of Process and Food Engineering, VNMKV, Parbhani.
Soybean grains of different varieties were cleaned thoroughly. Raw soybean was soaked in water at 100 °C temperature for 3 min, surface drying for 3h. Later on puffing was carried out in electrically operated roaster which works on HTST principle at 180 °C puffing temperature. Puffed soynuts prepared from four different varieties were cooled and then packed in Polypropylene (PP) bag for further analysis.

Determination of physical properties of different varieties of raw soybean and its puffed soynuts

Length (L), width (W) and thickness (T)

The various linear dimensions *viz.*, Length (L), width(W) and thickness (T) of different varieties of raw soybean and its puffed soynuts were determined by using vernier caliper having least count of 0.01 mm. (AOAC, 2005) [1].

Geometric mean diameter (GMD)

The geometric mean diameter (GMD) of different varieties of raw soybean and its puffed soynuts was computed by using the following relationship (Mohsenin, 1980) [12]:

$GMD = (LWT)1/3$ …….(1)

Where, L = Length of different varieties of raw soybean and its puffed soynuts (mm) W = Width of different varieties of raw soybean and its puffed soynuts (mm) T = Thickness different varieties of raw soybean and its puffed soynuts (mm) GMD = Geometric mean diameter of different varieties of raw soybean and its puffed soynuts (mm)

Sphericity and Aspect ratio (*As*)

The sphericity (*Φ)* of different varieties of raw soybean and its puffed soynuts prepared from different varieties of soybean was calculated using the formula given by Sharanagat and Goswami (2014) [17]. Aspect ratio was calculated by using relationship given by Singh *et al*. (2016) [18].

$$\Psi = \frac{(LWT)^{1/3}}{L} \quad \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

$$A_s = \frac{W}{\bar{a}} \text{ X } 100 \quad \ldots\ldots\ldots\ldots\ldots\ldots (3)$$

The unit volume of single grain (Jain and Bal, 1997) [5] was calculated as

$$V = \frac{\pi x G \bar{a} D x \bar{a}^2}{6(2\bar{a} - G \bar{a} D)} \quad \ldots\ldots\ldots\ldots\ldots\ldots (4)$$

Surface area (S) was calculated by using the expression given by (Singh *et al*.2016) [18],

$$S = \frac{\pi x G \bar{a} D x \bar{a}^2}{2\bar{a} - G \bar{a} D} \quad \ldots\ldots\ldots\ldots\ldots\ldots (5)$$

Thousand grains mass

The randomly selected thousand grains of different varieties raw soybean and its puffed soynuts was determined using an electronic balance having an least count of 0.01 g.

Bulk density (*ρ*b), true density (*ρ*t) measurements

The bulk density is the ratio of the mass sample of soybeans to its total volume. True density of the soybean was determined by the toluene displacement method. Toluene (40ml) was filled in 100 ml graduated measuring cylinder and 50g of grains were poured in it. The amount of toluene displaced was recorded. The true density was estimated as the ratio of sample mass to the volume of displaced toluene (Wandkar *et al*. 2013) [20].

Porosity (*έ*)

Porosity (*έ*) is the percentage of the volume of voids in grains. It was calculated as the ratio of the difference in the true density and bulk density to the true density and expressed by (Mohsenin 1980) [12]:

$$\varepsilon = \frac{\rho_b - \rho_t}{\rho_t} \quad \ldots\ldots\ldots\ldots\ldots\ldots (6)$$

Where, ρb = bulk density and ρt = true density.

Angle of repose

The angle of repose is the angle from the horizontal at which the material will rest in a pile. This was determined by using an open-ended cylinder. The cylinder was placed at the centre of circular plate and was filled with soybean grains. The cylinder was raised slowly until it formed a cone on the circular plate. The height of the cone was recorded.

The angle of repose, θ was calculated by using the following formula given by (Amin *et al*., 2004; Patel *et al*., 2013 and Kudos *et al*., 2016) [2, 14, 9]

$\theta = \tan\text{-}1 (2h/d)$ …… (7)

Where, θ is the angle of repose; *h* is the height of pile and *d* is the diameter of cone.

Puffing index

The puffing index of different variety of raw soybean and its puffed soy nuts was calculated according to Kaur *et al*., 2005 [8].

$$\text{Puffing index (\%)} = \frac{\text{Volume before puffing (ml)}}{\text{volume after puffing (ml)}} \quad \ldots\ldots\ldots\ldots (8)$$

Texture analysis

The textural properties (Hardness and Crispiness) of different varieties of raw soybean and its puffed soynuts were evaluated using texture analyzer (TA.XT. Plus Texture Analyzer, Stable Micro System, UK). The instrument was calibrated with 50 kg load cell. A 75mm cylindrical probe P/75 R was used for measuring the texture in terms of compression force. The target values were set at pre-test speed at 2mm/s, test-speed at 2mm/s, post-test speed at 10mm/s, strain at 3mm, and test force set at 0.005N. Grain of different varieties of raw soybean and its puffed soynuts placed onto platform and probe was allowed to compress 5mm return distance. Hardness values were considered as mean peak compression force and crispiness were measured in term of major positive number of peaks (Chauhan *et al*., 2003) [4].

Color parameter of different varieties of raw soybean and its puffed soynuts

The surface color of the different varieties of raw soybean and its puffed soynuts was measured using hunter colorimeter. Before testing the instrument was calibrated with standard black and white tiles supplied with instrument. The color readings were expressed in terms of L *, a *, b* values. The L * value represents the lightness to darkness gradation with range of 0 (black) to 100 (white), the a * value represent greenness to redness spectrum while the b-value represent the blue-yellow spectrum (Kakyaoglu, 2008) [6].

Sensory evaluation different varieties of raw soybean and its puffed soynuts

Puffed soynuts prepared from different variety of soybeans were evaluated on a 9 point hedonic scale by a trained and semi-trained panel. Sensory analysis was carried in the department of Processing and Food Engineering, VNMKV, Parbhani. The judges were given the samples puffed soy nuts prepared from different varieties of soybean for evaluation of sensory characteristics along with score card to record their degree of liking on 9 point hedonic scale wherein 9 stands for ''liked extremely'' to 1 for ''disliked extremely'.

Results and Discussion

Physical properties of different varieties of raw soybean and its puffed soynuts Linear dimensions and geometric mean diameter (mm)

The shape and size of grains are found useful tool in understanding the problem of separating grains from undesirable materials. It is an important criteria to decide the quality of puffed soynuts.

Table 1 presented the mean values of axial dimensions of different varieties of raw soybean and its puffed soynuts *viz*., Length, width and thickness. Further geometric mean diameters (GMD) was also computed. The average values of length of different varieties of raw soybean *viz*., MAUS-158, MAUS-621, MAUS-612 and JS-335 ranged between 5.83-6.71 mm, width between 5.12-5.52 mm, and thickness between 3.98-4.21 mm, respectively, whereas the length, width, thickness of puffed soynuts prepared from four different varieties varied from 6.40-7.17 mm, 5.61-6.18 mm and 4.36-4.97 mm, respectively. Highest linear dimensions such as length, width and thickness of puffed soynuts prepared from four different varieties was observed as 7.17, 6.18 and 4.97 mm for MAUS-612 variety. Chauhan *et al*., (2003) [4] also reported similar findings of length of puffed soynuts ranged between 6.28-7.21 mm maximum for shailazeet and minimum for JS-335 among the soybean of varieties PK-262, PK-416, PS-1024, PS-1042, Kalitur, Shilazeet, JS-335, PK-564 and PK-47. Theaverage geometric mean diameters of raw soybean of different varieties varied from 4.97-5.38 mm and 5.40-6.04 mm for puffed soynuts prepared from four different varieties respectively. Among puffed soynuts prepared from four different varieties, the highest average geometric mean diameters (GMD) of 6.04 mm was observed for puffed soynuts prepared from soybean variety of MAUS-612. Overall dimensions of soybean grains affect the expansion volume of puffed soynuts. This may be due to the reason of varietal differences of among different varieties of soybean.

Aspect ratio (%)

The aspect ratio of different varieties of raw soybean and its puffed soynuts *viz*., MAUS-158, MAUS-621, MAUS-612 and JS-335 are given in Table 1. The results of aspect ratios of raw soybean of different varieties of soybean ranged from 0.82-0.87% whereas, aspect ratios of puffed soynuts prepared from four different varieties of soybean ranged from 0.86-0.94%, respectively. The highest aspect ratio of 0.94% was noted in puffed soynuts prepared from soybean of JS-335 variety and lowest aspect ratio of 0.86% in soybean of MAUS-612 variety.

Surface area (mm2)

The values of surface area of different varieties of raw soybean and its puffed soynuts *viz*., MAUS-158, MAUS-621, MAUS-612 and JS-335 are presented in Table 1. The surface area of raw soybean and its puffed soynuts is useful to calculate the rate of heat transfer during HTST treatment. Surface areas of different varieties raw soybean ranged between 79.29-94.71 mm2 and puffed soynuts prepared from four different varieties ranged between 94.08-117.49 mm2 respectively. Among the puffed soynuts prepared from four different varieties, the highest surface area of 117.49 mm2 was observed for soynuts prepared from soybean of MAUS-612 variety.

Unit volume of grain (mm3) and Shape factor

The values of unit volume and shape factor of raw soybean and soynuts prepared from four different varieties are presented in Table 1.The unit volume of raw soybean of different varieties and its puffed soynuts varied from 65.67-84.97 mm3 and 84.68-118.25 mm3 respectively. Similarly the shape factor of different varieties of raw and puffed soynuts was ranged from 5.27-5.66 and 5.93-6.53 respectively. The highest unit volume of 118.25 mm3 was observed for soynuts prepared from MAUS-612 variety against the lowest unit volume of 84.68 mm3 for puffed soynuts of MAUS-158 variety and highest shape factor of 6.53 was observed for puffed soynuts of JS-335 variety.

Thousand grains mass (g)

The results of thousand grains mass of different varieties of raw soybean grains and its puffed soynuts *viz*., MAUS-158, MAUS-621, MAUS-612 and JS-335 are presented in Table 1. For the different varieties of raw soybean and its puffed soynuts prepared from different varieties, thousand grains mass varied from 124.98-140.59 g and 121.67-138.26 g respectively. MAUS-612 variety of puffed soynuts was found to be maximum of 140.59 g thousand grains mass compare to other different varieties of puffed soynuts.

Table 1: Physical properties of different varieties of raw soybean and its puffed soynuts

Properties	Varieties								SE		CD at 5%	
	MAUS-158		MAUS-621		MAUS-612		JS-335					
	Raw	Puffed	Raw	Puffed	Raw	Puffed	Raw	Puffed	Raw	Puffed	Raw	Puffed
L(mm)	6.21	6.44	6.41	6.55	6.71	7.17	5.83	6.40	0.071	0.069	0.109	0.205
W(mm)	5.36	5.61	5.42	5.77	5.52	6.18	5.12	6.01	0.052	0.049	0.142	0.148
T(mm)	3.98	4.36	4.18	4.61	4.21	4.97	4.11	4.39	0.123	0.140	0.354	0.415
GMD	5.14	5.40	5.26	5.58	5.38	6.04	4.97	5.53	0.048	0.059	0.165	0.174
Sphericity (%)	0.82	0.84	0.82	0.85	0.80	0.84	0.85	0.86	0.003	0.004	0.112	0.119
Aspect ratio in fraction	0.86	0.87	0.84	0.88	0.82	0.86	0.87	0.94	0.007	0.008	0.231	0.239
Surface area(mm 2)	84.34	94.07	89.70	100.17	94.71	117.49	79.29	97.79	2.195	2.283	6.125	6.749
Unit volume (mm3)	71.66	84.68	78.58	93.24	84.97	118.25	65.67	90.04	3.122	3.283	8.156	9.703
l(shape factor)	5.63	5.83	5.59	5.96	5.66	6.32	5.27	6.53	0.058	0.060	0.132	0.180
1000 seeds mass(g)	135.26	130.21	129.26	132.128	140.59	138.26	124.98	121.67	1.312	1.327	3.258	3.923

Bulk density(kgm3)	660.12	662.98	651.25	654.25	646.25	648.24	641.25	660.40	0.951	0.968	2.256	2.861
True density(kgm3)	1221.56	1201.11	1256.12	1248.26	1298.45	1258.21	1189	1140.10	10.123	10.451	29.514	30.890
Porosity (%)	45.87	44.80	45.12	47.58	49.28	48.47	44.98	42.08	0.5412	0.560	1.562	1.656
Angle of repose (∘)	22.15	30.19	25.26	30.16	27.17	31.25	22.12	27.26	0.301	0.332	0.978	0.980
Puffing index (%)	-	169.09	-	176.22	-	181.31	-	164.0		1.480	-	4.374

Bulk density and true density (kg/m3)

The physical properties such as bulk density and true density decreased during the puffing of soynuts prepared from different varieties of soybean. The bulk density of a grain gives the degree of kernel expansion during heat treatment of puffing of different varieties of soybean. Table 1 presents the results of bulk densities of different varieties of raw soybean grains and its puffed soynuts *viz*., MAUS-158, MAUS-621, MAUS-612 and JS-335. The bulk densities of different varieties of raw soybean grains and its puffed soynuts varied from 641.25-660.12 kg/m3 and 646.25-662.98 kg/m3. Similarly, the true densities of different varieties of raw soybean grains and its puffed soynuts ranged from 1189-1298.45 kg/m3 and 1140.10-1258.21 kg/m3.The maximum bulk density of 1298.45 kg/m3 was noted in puffed soynuts prepared from soybean variety MAUS-612 and minimum bulk density of 1140.10 kg/m3 was noted in puffed soynuts prepared from soybean variety JS-335. The decreased values of bulk density and true density of puffed soynuts prepared from different varieties coincides with the findings of Kaur *et al.*, (2005) [8] for different chickpea varieties. The bulk densities of raw soybean and its puffed soynuts was observed to be lower than the true densities. This could be the fact that air spaces in grain bulk that increases the volume while the mass is the same.this is the similar to the observation of Manuwa and Afuye (2004) [13].

Porosity (%)

The values of porosity for different varieties of raw soybean grains and its puffed soynuts are presented in Table 1.The porosity of different varieties of raw soybean ranged from 44.98-49.28%. The values of porosity of puffed soynuts prepared from different varieties of soybean decreased after puffing and found to be ranged from 42.08-48.47%. Similar trends were reported for sorghum seeds, soybean and Bambara groundnuts.

Angle of repose (°)

The angle of repose of different varieties of raw soybean grains and its puffed soynuts are presented in Table 1.The measure of angle of repose of different varieties of raw soybean and its puufed soynuts varied from 22.12-27.17° and 27.26-31.25° respectively. Also soynuts prepared from MAUS-612 variety was found to maximum value of angle of repose of 31.25° then the samples of soynuts prepared from other three varieties.

Sphericity (%)

Sphericity is necessary to describe the shape of the puffed soynuts. The sphericity of different varieties of raw soybean grains and its puffed soynuts are presented in Table 1. The sphericity of different varieties of raw soybean grains were distributed around 0.80- 0.85 and 0.84-0.86 respectively. The maximum value of sphericity of was noted in puffed soynuts of JS-335 variety.

Puffing index (%)

Puffing index was used to compare the puffing ability of different varieties of puffed soynuts. A summary of the puffing index of different varieties of puffed soynuts *viz*., MAUS- 158, MAUS-621, MAUS-612 and JS-335 are presented in Table 1. The puffing index of different varieties of puffed soynuts ranged from 164.0-181.31% noted maximum puffing index of 181.31% for soynuts prepared from MAUS-612 variety. Hence, MAUS-612 was found better in terms of puffing index as compare to other three varieties of puffed soynuts.

Textural properties of different varieties of raw soybean and its puffed soy nuts

Hardness and crispness are an important and desirable attributes for quality puffing of the food products. The textural analysis of different varieties of raw soybean and its puffed soynuts were performed using texture analyzer. Raw soybean and its puffed soynuts were placed individually on the plate and compression test was applied using cylindrical probe (diameter P/75). The texture of puffed soynuts was described by hardness, as the maximum peak force generated during the breaking test and crispness is defined number of positive peaks. The values of various textural properties of different varieties of raw soybeans and its puffed soy nuts are presented in Table 2.

The textural characteristics such as hardness and crispness of different varieties of raw soybeans soynuts varied from 203.16-342.19 N and 10-19 peaks respectively. The values of hardness and crispness of soynuts prepared from different varieties ranged from 43.49- 59.40N and 17-26 peaks. After Puffing, soynuts prepared from different varieties of soybean the values of hardness led to decrease and crispness increases as during puffing, soynuts becomes more crisp, crumble and brittle, which are the typical characteristics of puffed products. Kahyaoglu and Kaya (2006) [7] reported that during roasting of sesame seeds, fracture force decreased. Saklar *et al.*, (1999) [16] also observed the decreasing in the first fracture point during the roasting of hazelnuts. Therefore, puffed soynuts prepared from soybean of variety MAUS-612 was noted minimum hardness value of 43.49 N and maximum crispness of 26 peaks and found better in terms of textural characteristics as compare to other three properties.

Table 2: Textural characteristics of raw soybean and its puffed soy nuts

Variety	Raw soybean		Puffed soybean	
	Hardness(N)	Crispness(maximum no. of peaks)	Hardness(N)	Crispness(maximum no. of peaks)
MAUS-158	301.61	10	52.80	17
MAUS-621	260.12	14	48.10	22
MAUS-612	203.16	19	43.49	26
JS-335	342.19	13	59.40	20

Color properties of raw soybean and its puffed soy nuts

Hunter color parameter (L* value) of raw soybean and its puffed soynuts of different soybean varieties are presented in Table 3. Color parameters of the soynuts prepared from different soybean varieties is very important from consumer point of view as it appeals first to a person to purchase or consume it. The L* values of raw soybean from different varieties *viz*., MAUS-158, MAUS-621, MAUS-612 and JS-335 varied from 56.65 to 61.21. The L* values of puffed soynuts after puffing decreases for all the soybean varieties and ranged between 46.5- 53.10. This may be due to the fact that color of puffed soynuts become somewhat darker than the raw soybean and may be due to the effect of high temperature short time (HTST) applied for the puffing operation. A similar decreasing trend was observed by Kaur *et al.*, (2005) [8] for PDG-3 variety of chickpea which had lowest L* value among other five varieties of chickpea.

Table 3: Color values of different varieties of raw soybean and its puffed soynuts

Variety	Raw soybean	Puffed soybean
	L*	L*
MAUS-158	61.21	52.27
MAUS-621	60.75	53.10
MAUS-612	60.65	49.78
JS-335	56.65	46.50

Sensory evaluation of raw soybean grain and its puffed soy nuts

The study of sensory evaluation is one of the important parameter to study the quality characteristics of any puffed soynuts. The sensory parameters of different varieties of raw soybean and its puffed soynuts are presented in Table 3. Through visual observation color and appearance it was noted that soynuts prepared from soybean variety MAUS-612 scored highest score for color and appearance, flavor, texture, taste and overall acceptability. This may be due to the fact that soybean of MAUS-612 variety was bold in shape and size and having better physical, textural and sensory qualities than the soynuts prepared from other three varieties. Also soynuts prepared from MAUS-612 variety was found to be superior with respect to all quality parameters than the commercial sample of soynuts from the market.

Table 4: Sensory evaluation of raw soybean and its puffed soy nuts

Variety	Color & appearance	Flavor	Texture	Taste	Overall acceptability
MAUS -158	6.5	6.5	6.0	6.5	6.5
MAUS-621	8.0	7.5	7.5	8.0	7.0
MAUS-612	8.5	8.5	9.0	9.0	8.5
JS-335	7.5	8.0	7.0	8.0	7.5
Commercial sample	8	8.5	8	8	8.0
CD at 5%	0.158	0.269	0.504	0.382	0.688
S.E	0.053	0.091	0.171	0.130	0.232

Conclusion

The soynuts prepared from MAUS-612 variety was found to be better quality with respect to physical, textural characteristics, color and sensory qualities. Therefore MAUS-612 has been identified as most suitable variety among the varieties *viz*., MAUS- 158, MAUS- 621 and JS-335 studied for the production of better quality puffed soynuts.

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