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Studies on Screening of Sorghum Varieties for Popping

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The aim of the study was to screen the sorghum varieties (TNAU released sorghum varieties *viz.,* K 12, CO 30 and local variety) for popping. The physico - chemical characteristics of the raw and popped sorghum varieties were analysed. To optimize the pretreatment for the preparation of popped sorghum different soaking solutions were selected and studied their effect on popping. The sorghum grains were popped by using continuous popping machine at a temperature of 230 °C for 2.5 min. The popping characteristics were analysed for sorghum varieties pretreated with different soaking solutions. From the physico - chemical and popping characteristics, it was concluded that the K 12 variety showed the maximum values.

Key words: Sorghum, Physico - chemical characteristics, Soaking, Popping.

Sorghum (*Sorghum bicolor* (L.) Moench) popularly called as *jowar*, is the "king of millets" and is the fifth in importance among the world's cereals, after wheat, rice, maize and barley. It is a staple food grain in many Indian states. Sorghum is a powerhouse in terms of nutrients. It is grown especially in the arid and semi-arid regions. The major sorghum production areas today include the great plains of North America, Sub-Saharan Africa, North Eastern China and the Deccan Plateau of Central India, Argentina, Nigeria, Egypt and Mexico (Gundboudi, 2006). Sorghum is sown as a major crop in Maharashtra, Telangana and parts of Central India. It is considered for fodder and as well as food in some of the other southern regions. The millets world production in 2016 was 8944 hg ha^{-1}. In India, the millets production accounts to 11629 hg ha^{-1}. About half of world sorghum production is consumed directly by humans (FAO, 2016).

Convenient snack foods like popcorn, popped and puffed rice, popped sorghum, popped roasted and puffed soybean and other legumes are very popular (Jaybhaye, 2014). Popping is one such processing technique which not only improves the shelf life but also improves nutritional quality of the grains, it also improves the grain quality and adds flavour to the grains and hence the acceptability also gets improved (Gayatri Mishra *et al.,* 2014). Utilization of sorghum in the form of ready-to-eat pops is likely to improve its consumption significantly (Taylor *et al.,* 2006). Thus, the study aimed to evaluate the maximum popping efficiency in the TNAU realized sorghum varieties.

Material and Methods

Sorghum grain (*Sorghum bicolor*) varieties (CO 30 and K 12) were purchased in bulk from Regional Research Station, Kovilpatti and Krishi Vigyan Kendra, Arupukottai, Virudhunagar district. The local variety of sorghum purchased in bulk from the local market at Madurai city. Sorghum grains were brought to the laboratory (Plate - 1). The grains were thoroughly cleaned (manually by winnowing and sieving) to remove foreign materials such as dirt, stones, dust, immature grain, broken grains and unremoved chaffs.

Analysis of the physico - chemical characteristics of sorghum varieties and popped sorghum

The physico - chemical parameters such as length, breadth, thousand grain weight, specific gravity, hydration capacity and hydration index, solubility index and swelling power, gelatinization time and gelatinization temperature, water binding capacity, total amylose were estimated according to methods of (Chemists (US) and Analysis, 1965), water absorption capacity (Beuchat´s method, 1977), moisture content (Ranganna, 1995), starch content (Sadasivam and Manickam, 2008), reducing and total sugars (MC Donald and Efoley, 1960), protein (Ma and Zuazaga, 1942), crude fiber (Maynard, 1970), tannin and phytic acid (Schanderl, 1970), total ash (Hart and Fischer 1971), calcium (Clark and Collip, 1925), iron (Wong, 1928) and phosphorus (Fiske and SubbaRao, 1925) of all the selected sorghum varieties and the popped sorghum (K 12) were analysed.

Popping of sorghum

Sorghum varieties such as K 12, CO 30 and local variety were used for the popping. The flowchart for the preparation of popping of sorghum is given in Fig. 2. The sorghum varieties were cleaned to remove the dust, dirt, chaff and stones by winnowing and sieving. The cleaned grains were dried in a cabinet drier at 50 °C for 2 hrs. To optimize the soaking solution, the selected sorghum varieties of each were soaked separately in cold water, sugar (10 %), salt (10 %) and

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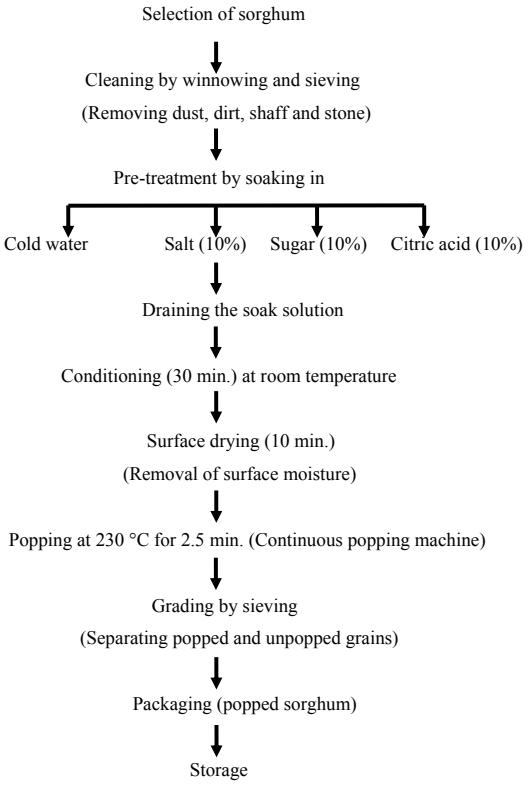
citric acid (10 %) at the proportion of 1:1.5 (1 part of grain and 1.5 part of soaking solution) for 1 hr. After 1 hr, the solution was drained out and conditioned for 30 min. The conditioned grains were dried for 10 min. to remove the surface moisture. The millets were popped using continuous popping machine at a temperature of 230 °C for 2.5 min. at 21.0 per cent moisture content (Plate - 2). The popped sorghum was graded to separate the popped and unpopped grains by sieving. The sieved grains were packed in polyethylene bags.

Figure - 1. Flow chart for processing of popped sorghum



Analysis of the popping characteristics sorghum varieties

The popping characteristics of the selected sorghum varieties such as popping performance and expansion ratio (Llopart *et al.,* 2016), popping percentage (Jaya Prakash Raya *et al.,* 2015) and popping yield (Gayatri Mishra *et al.,* 2015) were carried out by adopting standard procedure.

Results and discussion

Physico - chemical characteristics of sorghum varieties

The physico - chemical characteristics of selected sorghum varieties *viz.,* K 12, CO 30 and local variety was carried out separately and compared (Table - 1). The physical parameters of the sorghum varieties were ranged between 0.30 and 0.42 cm length, 0.31 and 0.37 cm breadth, 0.68 and 0.91 g ml^{-1} specific gravity, 34.10 and 40.60 g thousand grain weight, 29.10 and 33.80 g 1000 $seeds^{-1}$ hydration capacity, 0.71 and 0.99 per cent hydration index, 2.13 and 2.61 mg ml^{-1} water absorption capacity, 4.79 and 4.92 per cent solubility index, 4.52 and 4.76 g g^{-1} swelling power, 5.74 and 5.91g water binding capacity**,** 9.00 and 9.58 min gelatinization time and 81 and 84 °C gelatinization temperature.

Table 1. Physico - chemical characteristics of selected sorghum varieties

Characteristics	K 12	CO 30	Local
Length (cm)	0.40	0.30	0.42
Breadth (cm)	0.35	0.31	0.37
Specific gravity (g ml^{-1})	0.72	0.68	0.91
1000 grain weight (g)	40.60	38.90	34.10
Hydration capacity (g 1000 $seeds^{-1}$)	29.10	30.08	33.80
Hydration index (%)	0.71	0.77	0.99
Water absorption capacity (mg ml^{-1})	2.50	2.61	2.13
Solubility index (%)	4.92	4.85	4.79
Swelling power (g g^{-1})	4.76	4.69	4.52
Water binding capacity (g)	5.91	5.86	5.74
Gelatinization time (min)	9.00	9.42	9.58
Gelatinization temperature (°C)	81	83	84
Moisture (%)	11.48	11.51	10.90
Starch (g 100 g^{-1})	66.59	67.40	67.80
Amylose (%)	28.50	27.41	27.68
Amylopectin (%)	71.50	72.59	72.32
Protein (g 100 g^{-1})	12.25	11.86	11.42
Crude fibre (g 100 g^{-1})	2.20	1.86	1.75
Total sugars (g 100 g^{-1})	3.45	2.21	1.96
Reducing sugars (g 100 g^{-1})	1.94	1.48	1.40
Tannin (mg 100 g^{-1})	9.74	9.85	9.97
Phytic acid (mg 100 g^{-1})	125.8	131.85	132.21
Total Ash (g 100 g^{-1})	2.69	2.58	2.52
Calcium (mg 100 g^{-1})	28.25	28.12	27.95
Iron (mg 100 g^{-1})	4.65	4.58	4.46
Phosphorus (mg 100 g^{-1})	218.24	217.52	216.14

The selected varieties had 10.90 to 11.51 per cent moisture content and 66.59 to 67.80 per cent starch content. The protein contents of the varieties were 12.25, 11.86 and 11.42 per cent respectively for K 12, CO 30 and local variety. The amylose and amylopectin contents of three varieties varied from 27.41 to 28.50 per cent and 71.50 to 72.32 per cent respectively. The other chemical constituents such as crude fibre 1.75 to 2.20 g, total sugar 1.96 to 3.45 g, reducing sugar 1.40 to 1.94 g, tannin 9.74 to 9.97 mg, 125.8 to 132.21 mg phytic acid and 2.52 to 2.69 g total ash. The minerals *viz.,* calcium, iron and phosphorus were observed in all the sorghum varieties in varying quantum but slightly high values were found in K 12. The calcium content of three varieties ranged from 27.95 to 28.25 mg $100g^{-1}$, iron content from 4.46 to 4.65 mg $100g^{-1}$ and phosphorus content from 216.14 to 218.24 mg $100g^{-1}$.

Jambamma *et al.,* (2011) investigated the physico - chemical properties of pearled sorghum grain variety (K 9). The physico- chemical properties such as moisture content (%), bulk density (g cm^{-3}), true

density (g cm^{-3}) spherecity and 1000 kernel mass (g) were 10.51 ± 0.6, 0.81 ± 0.01, 1.24 ± 0.03, 0.84 ± 0.03 and 32.86 ± 1.44 respectively.

Shukla and Gour (2014) studied the physical and nutritional properties of maize varieties *viz.,* HQPM-1, HQPM-5, HKI-161, HKI-193 and JM-216. They reported that the length, width, thickness, 1000 grain weight, bulk density and spherecity of the maize varieties ranged between 0.91 and 1.15 cm^3 gm^{-1}, 8.66 and 9.37 cm^3 gm^{-1}, 5.23 and 4.95 cm^3 gm^{-1}, 38.00 and 39.10 g, 0.19 and 0.13 g ml^{-1} and 0.817 and 0.672 m^3 respectively.

Table 2. Popping characteristics of selected sorghum varieties

Varieties	Pre treatments	Popping performance (%)	Popping percentage (%)	Popping yield (%)	Expansion ratio (%)
K 12	Cold Water (T_1)	0.80	91.00	87.91	11.00
	Salt (T_2)	0.55	90.00	61.11	4.25
	Sugar (T_3)	0.53	92.00	57.60	5.00
	Citric acid (T_4)	0.34	93.00	36.55	3.00
CO 30	Cold Water (T_1)	0.50	89.00	54.94	7.20
	Salt (T_2)	0.42	91.00	46.15	3.50
	Sugar (T_3)	0.21	90.00	23.33	2.50
	Citric acid (T_4)	0.20	92.00	21.73	2.25
Local	Cold Water (T_1)	0.75	90.00	62.22	8.54
	Salt (T_2)	0.40	90.68	45.28	3.34
	Sugar (T_3)	0.35	91.25	25.89	2.69
	Citric acid (T_4)	0.15	91.00	20.59	2.16

T_1 - Nil T_2 - Salt (10 %) T_3 - Sugar (10 %) T_4 - Citric acid (10 %)

Kenghe *et al.,* (2015) evaluated the physical properties of newly evolved sorghum variety (*Cv. Phule suchitra*). The length, breadth, thickness, grain size, spherecity, surface area, volume, thousand grain weight and bulk density were 5.02 mm, 4.25 mm, 3.22 mm, 4.09 mm, 81.79 per cent, 46.39 mm^2, 28 mm^3, 42.47g and 775.85 kg m^{-3} respectively.

Popping characteristics of sorghum varieties

The popping characteristics of all the varieties (K 12, CO 30 and local variety) of sorghum for all the pretreatments were studied and the results are presented in Table - 2. The sorghum varieties pretreated with T_1, T_2, T_3 and T_4 showed the popping characteristics such as popping performance, popping percentage, popping yield and expansion ratio and the values varied between 0.15 and 0.80 per cent, 89.00 and 93.00 per cent, 20.59 and 87.91 per cent and 2.16 and 11.00 per cent respectively. The sorghum varieties (K 12) exhibited higher values in all the pretreatments and the values ranged from 0.34 to 0.80 per cent of popping performance, 90.00 to 93.00 per cent of popping percentage, 36.55 to 87.91 per cent popping yield and 3.00 to 11.00 per cent expansion ratio. Among the pretreatments, all the three samples soaked in cold water showed the maximum popping characteristics *viz.,* popping performance, popping percentage, popping yield and expansion ratio.

K 12 **CO 30** **Local**

Plate 1. TNAU released sorghum varieties

The foxtail millet was pretreated with salt, sugar and citric acid solutions (each 1.0 to 5.0 % in 100 g of grains). The popping percentage was higher for the salt (sodium chloride) pretreated grains (Gurupavithra *et al.,* 2013).

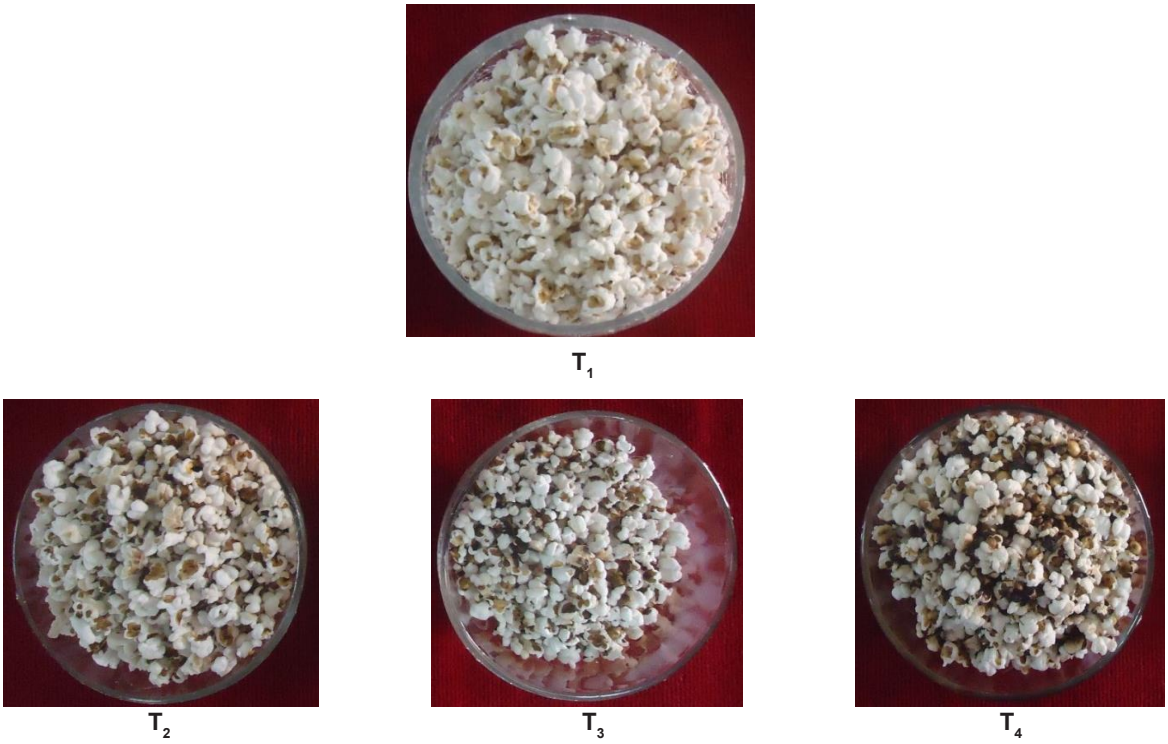


Plate 2. Sorghum grains pretreated with soaking solutions

Jaya Prakash Raya *et al.,* (2015) reported that the yield percentage of the corn pretreated with water (81.84 %) was high compared to that of the corn pretreated with citric acid at 10 per cent (65.86 %).

Table 3. Physico - chemical characteristics of popped sorghum (variety K 12)

Characteristics	Values
Popping performance (%)	0.80
Popping percentage (%)	91.00
Popping yield (%)	87.91
Expansion ratio (%)	11.00
Solubility index (%)	8.62
Swelling power (g g^{-1})	5.06
Water binding capacity (g)	8.35
Gelatinization time (min)	7.00
Gelatinization temperature (°C)	76
Moisture (%)	9.10
Starch (g 100 g^{-1})	71.25
Amylose (%)	25.60
Amylopectin (%)	74.40
Protein (g 100 g^{-1})	10.50
Crude fibre (g 100 g^{-1})	2.50
Total sugars (g 100 g^{-1})	2.75
Reducing sugars (g 100 g^{-1})	1.69
Tannin (mg 100 g^{-1})	6.89
Phytic acid (mg 100 g^{-1})	121.56
Total Ash (g 100 g^{-1})	2.34
Calcium (mg 100 g^{-1})	21.52
Iron (mg 100 g^{-1})	4.09
Phosphorus (mg 100 g^{-1})	214.19

Gayatri Mishra *et al.,* (2015) investigated the physico - chemical properties and popping properties of four varieties (Nandel, local red, Mugad and GJ 42). Among the four varieties, Mugad grain variety showing the highest popping qualities (81.2 per cent), small grain size (3.04 mm), high bulk density (833.4 kg m^{-3}) and thousand grain weight (30.1 g).

Physico - chemical characteristics of popped sorghum (variety K 12)

The physico - chemical characteristics of the popped sorghum (selected variety K 12) was carried out and the results are presented in Table - 3. The physical parameters of popped sorghum (K 12 variety) were 0.80 per cent of popping performance, 91.00 per cent of popping percentage, 87.91 per cent popping yield, 11.00 per cent expansion ratio, 8.62 per cent solubility index, 5.06 g g^{-1} of swelling power, 8.35 per cent of water binding capacity, 7.00 min. of gelatinization time and 76 °C of gelatinization temperature. The freshly prepared popped sorghum has pure white in colour and strong flavor as noted in maize popcorn flavour. The texture of the popped sorghum was slightly coarse, crisp and pliable. The chemical parameters were 9.10 per cent moisture, 71.25 per cent starch, 25.60 per cent amylose, 74.40 per cent amylopectin, 10.50 per cent protein, 2.50 g crude fibre, 2.75 g total sugar, 1.69 g reducing sugar, 6.89 mg tannin, 121.56 mg phytic acid, 2.34 g total ash, 21.52 mg calcium, 4.09 mg iron and 214.19 mg phosphorus per 100g.

Sankarapandian, (2000) studied 23 samples of

jowar for physical, physiological cooking and popping characteristics. He concluded that K 4 and TWC 120 are suitable for cooking purposes, whereas K5, IS 3541, K tall, CO 10 and MMK suitable for popping. K 4 and TWC 120 showed higher 500 grain weight, swelling capacity. K 7, K 10, CO 26 and SPV 1041 recorded higher density of grains. CO 25 and V 47 recorded higher grain volume and diameter of the grain.

Gundboud,i (2006) studied the thousand kernel weight, volume of density of popped sorghum cultivars grown in Kharif and Rabi season. The recorded values ranged from 15.60 - 20.30 g of thousand kernel weight, 18.67 - 24.67 ml of volume, 0.83 - 0.80 g ml^{-1} of density. The mean thousand kernel weight and volume of rabi cultivars was higher than kharif cultivars.

Conclusion

The TNAU released sorghum variety K 12 showed maximum physico - chemical and popping characteristics than the other varieties. The popped sorghum can be utilized for the preparation of snacks (nutri bar, bhel puri, masala popped, sweet balls) health mix and breakfast cereal.

References

AOAC 2000. Official methods of Analysis of the Association of Official Agricultural Chemists. Association of Analytical Chemists, Washington, DC, New York. 64-74

Clark and Collip. 1925. Estimation of calcium. *J. Bio.Chem.* **63:** 641. edition

Fiske and Subbarao. 1925. Estimation of phosphorus. *J. Biological Chem,* **66:** 375

Gayatri Mishra D.C., Joshi and Brajesh Kumar Panda. 2014. Popping and Puffing of Cereal Grains: A Review. *Journal of Grain Processing and Storage*, **1(2):** 34-46

Gundboudi, Zeenath A. 2006.Nutritional and Processing Qualities of Pop Sorghum Cultivars and Value Addition. PhD Thesis, UAS, Dharwad

Gurupavithra S., A. Jayachitra and K. Dilna. 2013. Study on biochemical and nutritive value of popped foxtail millet. *Int. J. Pharm Bio Sci,* **4(2):** 549-558

Hart A.M. and H.J. Fisher. 1971. Modern Food Analysis. Springer Farley, Berlin, Heidel berry, New York. P: 64-74

Jambammal, K. and R. Kailappan. 2011. Study of Physico-Chemical Properties of Food Grain Sorghum and Product Ready-to-Cook Mix Food from Sorghum. *International Journal of Recent Scientific Research,* **1(3):** 96-99

Jaya Prakash Raya B., D. Ashwin Kumar, Ravindra Babu and A. Sravanthi. 2015. Effect of pre-treatment on puffing of finger millet, bengal gram and maize and their flours. *International Journal of Agricultural Engineering*, **8(2):** 248-254

Kenghe R.N., M.S. Jadhav, C.A. and Nimbalkar. 2015. Physical properties of sorghum (sorghum bicolor) grains as a function of moisture content. *International Journal of Engineering Sciences & Research Technology.* **4(10):** 496-502

Ma,T. and G. Zuazaga. 1942. *Ind. Eng. Chem., Anal. Edn.***14:**280:1-2, 7-11 and 13

Malleshi, N.G. and H.S.R. Desikachar 1982. Formulation of weaning food with low hot paste viscocity based on malted ragi and green gram flour. *J Food Sci,* **19:** 193-197

Maynard, A.J. 1976. Methods in Food Analysis. Academic press, New York. 176

McDonald and J.B.Y. Efoley. 1960. Estimation of total and reducing sugar content, *Journal of Agricultural Chemistry*, **43**: 645

Mishra, Gayatri, Dinesh C. Joshi, Debabandya Mohapatra, and V. Bhushan Babu. 2015. Varietal Influence on the Microwave Popping Characteristics of Sorghum. *Journal of Cereal Science,* **65:** 19-24

Ranganna S. 1995. Manual of analysis of fruits and vegetables products. *Tata McGraw Hill publishing Co*, Ltd., New Delhi. P. **1-2**; 7- 13

Raya J.P., B. A. Kumar, D. R. Babu and A. Sravanthi. 2015. Effect of Pre-Treatment on Puffing of Finger Millet, Bengal Gram and Maize and Their Flours. *International Journal of Agricultural Engineering*, **8(2):** 248-254

Sadasivam, S. and A. Manickam. 2008. Biochemical methods, 3rd Edn, New Age International (P) Limited Publishers. 193, 194, 201, 203-206

Sankarapandian, R. 2000. Physical-Physiological-Cooking and Popping Characteristics of Some Jowar Varieties and Their Intercorrelation and Regression Analysis. *Journal of Food Science and Technology (Mysore),* **37(3):** 327-329

Shukla Shashita and Shashi Gour. 2014. Evaluation of Physical, Nutritional and Popping Quality of Some Maize (Zea Mays) Varieties. *Asian Journal of Dairy & Food Research,* **33:** 285-291

Taylor J.R., T.J. Schober and S.C. Bean. 2006. Novel and non food uses for sorghum and millets. *Journal of Cereal Science,* **44:** 252-271

Wong. 1928. Estimation of iron. In: B.L. Oser (ed.). Hawks physiological chemistry, 14th edition

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