e - ISSN - 2348 - 2168
Print ISSN - 2348 - 215X

Acta Biomedica Scientia

Journal homepage: www.mcmed.us/journal/abs

SELECTION OF GENOTYPE AND DEVELOPMENT OF TECHNOLOGY FOR SORGHUM *POPS* PRODUCTION

[1*]Chavan UD, [2]Dalvi US, [3]Pawar GH and [4]Shinde MS

[1]Senior Cereal Food Technologist. [2]Assistant Professor of Biochemistry. [3]Senior Research Fellow. [4]Assistant Sorghum Breeder, Sorghum Improvement Project, Mahatma Phule Krishi Vidyapeeth, Rahuri, India.

Article Info

Received 29/01/2015
Revised 16/02/2015
Accepted 19/03/2015

Keywords :-
Sorghum pops, pops, nutritional quality, amino acid profile, mineral elements.

ABSTRACT

Fully mature grains of four sorghum genotypes and maize grains were used for the preparation of pops. Small popping machine, big popping machine (popcorn machine), micro-wave and salt-*bhatti* were used for the preparation of sorghum pops. The sorghum genotype RPOSV-3 (Phule Panchami) pops gave very bright white colour and extra-large, fully open size than other genotypes. The popping percentage was higher in RPOSV-3 (87.4%) and processing losses were less (3.4%) than the other genotypes studied. The organoleptic properties of the sorghum pops were similar to that of corn pops but had very good taste than the popcorn. Nutritional quality of sorghum pops, grits and pop flour is also good. It can be stored one year without any adverse effect in plastic bags with proper sealing. The economical returns from pop sorghum are very good for commercialization of the pop sorghum.

INTRODUCTION

Sorghum (*Sorghum bicolor* L. Moench) is the king of cereals and is one of the important food and fodder crops in dry lands of tropical Africa, India and China [1]. India ranks second in the world for sorghum production and first with respect to many regionally important crops like millets and pseudo-cereals. Sorghum is the principal staple food of Maharashtra, and is also an important food of Karnataka, Madhya Pradesh, Tamil Nadu and Andhra Pradesh. Sorghum can be milled to produce starch or grits (semolina/rava) from which many ethnic and traditional dishes can be made. The most common products are leavened and unleavened breads, porridges, boiled grains and steam cooked products such as couscous. Sorghum flour also makes an excellent fry coating for fish, chicken and beef. Sorghum is also used in the preparation of several snacks and for popping, chewing and malting [2,3,4,5].

Sorghum grains are polished with a pearling machine and processed in to flour as well as *rava* (*suji*) of different particle size (coarse *rava*, medium *rava* and fine *rava*). Nowadays sorghum can be processed in to various products such as pops, starch, and grits (semolina/*rava*) from which many ethnic/niche food products can be made. This reduces the coarseness of the product made and also removes the bitterness that is associated with the pericarp of the grain. Sorghum does not have gluten and hence becomes a very good ideal gluten free energy source for the people suffering from wheat or gluten allergies.

There is a considerable variation in sorghum for levels of proteins, lysine, lipids, carbohydrates, fiber, calcium, phosphorus, iron, thiamine and niacin [3]. Sorghum has chemical composition similar to or better than rice and wheat in some respects. The grains contain higher fiber and non-starchy polysaccharides and starch with some unique characteristics. Protein quality and essential amino acid profile of sorghum is better than man of the cereals. Sorghum in general is rich source of B-complex vitamins [6,7,8].

Corresponding Author

Chavan UD
Email: - uttamchavan08@gmail.com

Grain sorghum is rich in fiber and minerals apart from having a sufficient quantity of carbohydrates (72%), proteins (11.6%) and fat (1.9%). Starch is the major constituent of the grain. Grain sorghum protein contains albumin globulin (15%), prolamin (26%) and glutelin (44%). Sorghum does not contain gluten and hence the dough does not have stickiness, to roll with the chapatti roller. The flour from sorghum is gluten free and is a safe energy source for people allergic to gluten. Minimal amounts of flavan-4-ols and phytic acid are present in white sorghum [7].

For corn pop preparation various parameters such as starch and lipid properties, cell wall structure and other components were studied by Reeve and Walker [9-16].

There is a need to popularize sorghum foods as sorghum with its high mineral and fiber content and with low or slow starch digestibility makes an ideal food for diabetic and obese population in the urban as well as rural society. To identify specific genotype for specific purpose from sorghum is scanty. It was therefore; felt to identify the genotype for sorghum pops purpose which will give benefits to the farmers and the consumers too. Nowadays agro-tourism business is increasing in the rural area and in that contest supplying sorghum pops as a niche product get the more profit to the farmer/producer.

MATERIALS AND METHODS

Materials

Two genotypes of *rabi* sorghum which are popular at local/village level for pops and one new genotype developed for specifically for sorghum *pops* (RSGV 3; Phule Panchami) and M 35-1 were grown at Sorghum Improvement Project, Mahatma Phule Krishi Vidyapeeth, Rahuri and maize grains were procured from the local market.

Pops preparation

Fully mature grains of four sorghum genotypes and maize grains were used for the preparation of *pops*. Small popping machine, big popping machine (popcorn machine), micro-wave and gas fire-*bhatti* were used for the preparation of sorghum *pops*. Sample grains were tempered to 14% moisture content on a dry weight basis. The popping percentage was calculated on the basis of number of grains popped as well as on weight basis. The popped sorghum was quickly transferred to a measuring cylinder and the expansion at the highest point was recorded.

Nutritional and chemical analysis

The crude protein, hectoliter weight of grains, *pops* and expansion volume of sorghum *pops* was measured by using standard method of AOAC [17]. The colour of grains and size of pops was measured by physical observations. Starch content was determined using standard method of McCready *et al*., [18]. Total soluble sugars were determined using Dubois *et al*., [19] method. Free amino acids were estimated by using standard method of Moor and Stein [20]. Amino acid profile, mineral content, vitamins and antinutritional factors in the sorghum grain, *pops* and pops flour were determined using NIR Spectrometer, SpectraAlyzer, Zeutec Make, Germany. Soluble proteins were determined using method of Lowery *et al*., [21].

Sensory evaluation

The sorghum *pops* prepared were subjected for the sensory evaluation to a panel of ten semi-trained judges. Parameters evaluated by the judges included colour and appearance, texture, aroma/flavour, taste and overall acceptability. For the sensory evaluation of sorghum *pops*, 1 to 9 point hedonic scale [Like extremely (Excellent) – 9, Like very much (Very good) – 8, Like moderately (Good) – 7, Like slightly – 6, Neither likes nor dislike – 5, Dislike slightly – 4, Dislike moderately – 3, Dislike very much – 2, Dislike extremely – 1] was used [22]. The NDF, ADF and IVDMD were determined from sorghum fodder by standard method of Van Soest [23] and Van Soest *et al*., [24] respectively.

Statistical analysis

All analysis was conducted in triplicate and the average and their statistical analysis is given in the results as per the standard procedure of Panse and Sukatame [25].

Table 1. Popping quality of popped *rabi* sorghum variety RPOSV 3 (Phule Panchami)*

Popping quality parameters	Genotypes				
	RPOSV 3	Local 1	Local 2	M 35-1	Maize
Popping (%) on gain number basis	98	82	63	59	98
Expansion volume (ml/g)	6.5	4.8	4.6	2.6	19.6
Colour of pop grains	White	White	White	White	Creamy white
Size of popped grains	Extra-large white fully opened & excellent	Large white	Small whitish	Small whitish, yellow	Extra-large, fully opened, creamy white, excellent

*Results are means of 10 determinations.

Table 2. Popping percentage (on wt. basis) of various *rabi* sorghum genotypes*

Genotype	Popped Grains %	Un-popped grains %	Processing losses %	Grain price (Rs./Kg)
RPOSV 3	87.4	8.8	3.8	20
Local 1	73.2	18.6	8.2	20
Local 2	56.6	36.4	7.0	20
M 35-1	38.0	53.8	8.2	18
Maize	82.6	4.0	13.4	52
Range	38.0-87.4	4.0-53.8	3.8-13.4	-
Mean	67.56	24.32	8.12	-
S. E. ±	18.14	18.45	3.09	-
C. D. at 5% (n=3)	54.42	55.34	9.28	-

***Results are means of three determinations.

Table 3. Chemical constituents of sorghum pop grains (RPOSV-3; Phule Panchami)*

Parameter	RPOSV 3	Local 1	Local 2	M 35-1	Maize	S.E.±	CD at 5%
Starch (%)	75.1	70.1	74.6	64.4	69.7	3.88	11.66
Protein (%)	8.65	8.15	7.03	10.47	9.03	1.12	3.38
Soluble protein (%)	1.00	1.13	0.93	1.43	0.59	0.27	0.82
Total sugars (%)	1.25	1.11	0.87	1.92	0.93	0.37	1.13
Free amino acids (mg/100g)	48.70	51.36	38.13	83.40	23.67	19.74	59.23
Hectoliter wt. (Kg/hl)	81.11	79.36	77.76	79.21	142.08	25.11	75.33

***Results are means of three determinations.

Table 4. Nutritional constituents of *pops* prepared from *pop* sorghum variety RPOSV-3*

Parameter	Starch (%)	Protein (%)	Soluble protein (%)	Total sugars (%)	Free amino acids (mg/100g)
RPOSV 3	75.8	8.52	0.85	1.05	23.17
Local 1	70.9	8.01	1.01	0.95	21.16
Local 2	75.1	6.93	0.86	0.71	13.05
M 35-1	65.0	10.23	1.33	1.70	33.11
Maize	70.3	9.00	0.55	0.78	13.12
Range	65.0-75.8	8.01-10.23	0.55-1.33	0.78-1.70	13.05-33.11
Mean	71.42	8.54	0.92	1.04	20.72
S. E. ±	3.88	1.09	0.25	0.35	7.43
C. D. at 5%	11.66	3.27	0.76	1.06	22.30

***Results are means of three determinations.

Table 5. Organoleptic evaluation of sorghum pops RPOSV-3 (Phule Panchami)*

Genotype	Colour & appearance	Flavour	Crispness	Taste	Overall acceptability	DMR rank
RPOSV 3	8.6	7.4	8.0	8.4	8.1	2
Local 1	7.4	7.2	6.8	7.6	7.3	3
Local 2	6.4	6.8	6.6	7.4	6.8	4
M 35-1	6.2	7.0	5.6	6.8	6.4	5
Maize	7.8	8.0	8.2	8.6	8.2	1
Range	6.2-8.6	6.8-8.0	6.6-8.2	6.8-8.6	6.4-8.2	-
Mean	7.28	7.28	7.04	7.76	7.36	-
S.E. ±	0.89	0.41	0.95	0.66	0.70	-
C.D. at 5%	2.67	1.24	2.87	1.99	2.12	-

*Ten semi-trained judges were used for the sorghum *pops* organoleptic/sensory quality evaluation and 1 to 9 point hedonic scale used for scoring. DMR = Duncan multiple range rank.

Table 6. Nutritional composition of sorghum grains (Phule Panchami), pops, pop grits and pops' flour*

Parameter	Grain	Pops	Pops' grits	Pops' flour	SE ±	CD at 5%
Crude protein, %	8.65	9.04	8.37	10.82	0.95	2.86
Soluble proteins, %	1.00	1.59	1.20	1.15	0.21	0.65
Lipids, %	1.52	1.17	1.21	0.85	0.23	0.71
Crude fiber, %	3.94	2.05	2.67	3.12	0.68	2.07
Total sugars, %	1.25	1.03	1.15	1.05	0.08	0.26
Starch, %	75.01	75.26	67.35	66.33	4.18	12.56
Ash, %	2.86	2.72	2.64	2.53	0.12	0.36
Mineral elements						
Calcium, mg/100g	14.51	25.81	27.29	26.95	5.29	15.90
Potassium, mg/100g	517.57	254.35	215.53	197.98	129.33	388.01
Phosphorus, mg/100g	524.78	510.81	519.15	516.73	5.01	15.04
Sodium, mg/100g	29.93	13.11	11.90	8.61	8.27	24.82
Iron, mg/100g	9.49	6.48	5.31	7.76	1.55	4.66
Magnesium, mg/100g	219.58	217.02	207.13	211.87	4.79	14.38
Zinc, mg/100g	4.28	4.19	4.00	4.24	0.10	0.32
Copper, mg/100g	0.84	0.76	0.75	0.79	0.03	0.11
Manganese, mg/100g	2.05	2.07	2.07	1.81	0.11	0.33
Vitamins						
β-Carotene, µg/100g	52.75	3.78	-	-	-	-
Thiamine, mg/100g	0.45	-	-	-	-	-
Riboflavin, mg/100g	0.32	0.34	0.36	0.35	0.01	0.04
Niacin, mg/100g	1.63	-	-	-	-	-
Folic acid, µg /100g	31.26	9.54	9.29	9.77	9.40	28.23
Antinutritional factors						
Free amino acids, mg/100g	93.09	89.04	85.70	87.50	2.72	8.18
Phenolics, g/100g	1.72	1.65	1.17	1.65	0.21	0.66
Oxalic acid, mg/100g	14.48	-	-	-	-	-
Phytic phosphorus, mg/100g	65.45	39.79	42.16	42.68	10.40	31.23

*Results are means of three determinations. - Not detected

Table 7. Amino acid composition of sorghum grains (Phule Panchami), *pops*, *pop* grits and *pops*' flour (g/16 g Nitrogen)*

Parameter	Grain	*Pops*	*Pops*' grits	*Pops*' flour	S.E. ±	CD at 5%
Alanine	7.15	6.44	6.10	5.39	0.63	1.90
Arginine	4.89	3.30	4.72	3.73	0.35	1.08
Aspartic acid	8.72	6.07	5.33	7.58	1.31	3.95
Cysteine	1.22	0.92	0.91	0.77	0.16	0.49
Glutamic acid	20.11	23.28	24.45	24.89	1.86	5.60
Glycine	3.89	3.56	3.39	2.44	0.53	1.62
Histidine	1.89	2.49	2.77	2.72	0.34	1.05
Isoleucine	3.23	3.95	4.04	4.73	0.53	1.59
Leucine	11.86	15.46	16.72	17.86	2.25	6.76
Lysine	2.75	1.71	1.63	1.66	0.46	1.41
Methionine	1.49	1.58	1.63	1.72	0.08	0.25
Phenylalanine	4.32	4.67	4.58	5.18	0.31	0.94
Proline	5.28	5.30	5.34	3.96	0.58	1.75
Serine	4.24	4.09	3.89	3.66	0.21	0.65
Threonine	3.19	3.33	3.42	3.58	0.14	0.42
Tryptophan	1.05	0.77	0.65	0.51	0.19	0.60
Tyrosine	3.48	4.57	4.91	4.57	0.53	1.62
Valine	2.46	2.40	2.33	2.39	0.04	0.14

*Results are means of three determinations.

Table 8. Economical returns from *pop* sorghum

Variety	Grain yield Kg/ha	Net grain yield used for popping (kg/ha)	Market rate Rs/Kg	Total price of grain (Rs)	Processing cost (Rs)	Cost of grain with processing (Rs)	Market price of processed product (Rs)	Net expected return (Rs)
RPOSV 3	1376	1202	18/-	24768/-	18824/-	43592/-	15,6260/-	1,12,668/-
M 35-1	1712	-	20/-	34240/-	-	34240/-	34240/-	Nil

Note:
1. Processing cost 76% on raw material cost: (Ref: Bakery products book, 2008; J. K. Chavan and V. A. Dhotre)
2. Sorghum pop recovery from 1 kg grain produces 26 packets of 500 ml/25g each.
3. Present market price of sorghum pop packet is Rs. 5/each (i.e. Rs. 130/kg grain)
4. Un-popped grains 8.8%, popping losses 3.8% (i.e. total loss is 12. 6%).

Table 9. Fodder quality of *rabi* RPOSV-3 (Phule Panchami) as compare to the local genotypes*

Genotype	Crude protein (%)	Total sugars (mg/100g)	Crude fiber (%)	NDF (%)	ADF (%)	IVDMD (%)
RPOSV 3	4.78	613	32.13	63.19	41.13	53.07
Local 1	4.69	638	31.36	61.29	42.16	52.03
Local 2	5.13	621	30.87	62.15	40.31	52.67
M 35-1	5.81	635	33.19	64.57	41.23	53.23
Maize	-	-	-	-	-	-
Range	4.69-5.81	613 - 638	30.87-33.19	61.29-64.57	40.31-42.16	52.03-53.23
Mean	5.10	627	31.89	62.80	41.21	52.75
S.E. ±	0.44	10.2	0.87	1.22	0.65	0.46
C. D. 5%	1.32	31	2.63	3.67	1.97	1.39

*Results are means of three determinations. NDF= Neutral detergent fiber; ADF = Acid detergent fiber; IVDMD = *In-Vitro* dry matter digestibility, - = Not determined.

RESULTS AND DISCUSSION

Fully mature grains of four sorghum genotypes and maize grains were used for the preparation of *pops*. Small popping machine, big popping machine (*pop*corn machine), micro-wave and salt-*bhatti* were used for the preparation of sorghum *pops*. In salt-*bhatti* method iron pan was kept on the gas and salt was added into it and temperature rose to 290 ^{0}C. Then tempered sorghum grains were poured into hot salt for popping. The salt-*bhatti* was the very good for good quality pops preparation from pop sorghum. The popping percentage on the basis of grain number and weight basis were calculated. The new genotype RPOSV-3 gave higher percentage of popping. The expansion volume was also higher than the local genotypes but less than maize (Table 1). The RPOSV-3 pops gave very bright white colour and extra-large, fully open size than other genotypes. The popping percentage was higher in RPOSV-3 (87.4%) and processing losses were less (3.4%) than the other genotypes studied (Table 2). The chemical composition of the grains and pops was found similar except having higher starch content in grains as well as in *pops* prepared from pop sorghum (Table 3, 4).

The organoleptic score of the *pops* showed that the RPOSV-3 having similar rank to that of Maize *pops* (Table 5) having 8.1 overall acceptability score. The sorghum pops can be converted in to *pop* grits and flour and then use for various food items. The nutritional composition of the sorghum grain, *pop*, grits and *pops*' flour also showed very good source of minerals and vitamins (Table 6). The *pops*' grits and flour shoed slightly lower level of these elements due to processing losses. The antinutritional factors also reduced in the processed products (Table 6). The amino acid profile of sorghum grain, *pops*, *pops*' grits and *pops*' flour also showed promising results (Table 7). The production cost of sorghum *pops* showed that if the crop management and processing technology used properly then farmer can get nearly Rs. 1, 12, 668/- net profit from one hectare area of *pop* sorghum. The economical returns from *pop* sorghum are very good for commercialization of the *pop* sorghum (Table 8). Farmers also get fodder from the sorghum *pop* variety. The fodder/stover quality of the RPOSV-3 is similar to that of other local genotypes (Table 9).

CONCLUSION

RPOSV-3 (Phule Panchami) having very good popping characteristics as well as nutritional quality as compared to the other local genotypes. It can be stored one year without any adverse effect in plastic bags with proper sealing. The economical returns from *pop*sorghum are very good for commercialization of the *pop* sorghum.

RERERENCES

1. Shobha V, Kasturiba B, Naik RK and Yenagi N. (2008). Nutritive Value and Quality Characteristics of Sorghum Genotypes. *Karnataka Journal of Agriculture Science*, 20, 586-588.
2. Rao Prasada KE and Murty DS. (1981). Sorghum for Special Uses. Proceedings of the International Symposium on Sorghum Grain Quality, 129-134.
3. Chavan UD, Patil JV and Shinde MS. (2009). Nutritional and *roti* quality of sorghum genotypes. *Indonesian Journal of Agriculture Science*, 10, 80-87.
4. Sajjanar GM, Patil PB, Biradar BD, Hemalatha S, Tonapi VA, Elangovan M, Raghavendra Rao KV and Seetharama, N. (2009). Special Sorghum Varieties of North Karnataka for Traditional and Novel Foods, Value Addition and Entrepreneurship Development, National Research Center for Sorghum, Rajendranagar, Hyderabad and All India Co-ordinated Sorghum Improvement Project, Regional Agricultural Research Station, Bijapur, 586 101, Karnataka. Pages, 69 ISBN 81-89335-22-27.
5. Unhale DS, Sakhale BK, Ranveer RC and Pawar VD. (2012). Studies on shelf life extension of sorghum *roti*. *International Food Research Journal*, 19, 733-736.
6. Gopalan C, Sastry BVR and Balsubramanyam SC. (2000). Nutritive Value of Indian Foods. National Institute of Nutrition. I.C.M.R, Hyderabad.
7. Chavan UD and Patil JV. (2010). Grain Sorghum Processing. IBDC, Publishers, Lucknow, India, 440.
8. Patil PB, Sajjanar GM, Biradar BD, Patil HB and Devarnavadagi SB. (2010). Technology of *hurda* production by microwave oven. Journal of Dairying, Foods and H. S, 29, 232-236.
9. Reeve RM and Walker HG. (1969). The microscopic structure of popped cereals. *Cereal Chem*, 46, 227-241.
10. Hoseney RC, Zelezank K and Abdelrahman A. (1983). Mechanism of popcorn popping. *J. Cereal Sci*, 1, 43-52.
11. Song A, Eckhoff SR, Paulsen M and Litchfield JB. (1991). Effect of kernel size and genotype on popcorn popping volume and number of unpopped kernels. *Cereal Chem*, 68, 464-467.
12. Song A and Eckhoff SR. (1994). Optimum popping moisture content for popcorn kernel of different sizes. *Cereal Chem*, 71, 458-460.
13. Karkalas J, Ma S, Morrison WR and Pethrick RA. (1995). Some factors determining the thermal properties of amylase inclusion complexes with fatty acid. *Carbohydr. Res*, 268, 233-247.
14. Tian Y, Buriak P and Eckhoff SR. (2001). Effect of hybrid and physical properties of individual popcorn kernels on expansion volume. *Cereal Chem*, 78, 578-582.
15. Park D and Maga JA. (2002). Effects of storage temperature and kernel physical condition on popping qualities of popcorn hybrids. *Cereal Chem*, 79, 572-575.
16. Han JA, BeMiler JN, Hamaker B and Lim ST. (2003). Structural changes of debranched corn starch by aqueous heating and stirring. *Cereal Chem*, 80, 323-328.
17. A.O.A.C, (1990). Official Methods of Analysis, 15th Edn Association of Official Analytical Chemists Washington DC, 113-127.
18. McCready RM, Guggolz J, Silviera V and Owens HS. (1950). Determination of starch and amylose in vegetables. *Anal Chem*, 22, 1156-1158.
19. DuBois M, Gilles JK, Hamilton JK, Robers PA and Smith F. (1956). Colorimetric method for determination of sugars and related substances. *Analyt Chem*, 28, 350-356.
20. Moore S and Stein WH. (1948). In, Methods Enzymol. (Eds, Colowick, S. P. and Kaplan, N. D.), Academic Press, New York, 3, 468.
21. Lowery OW, Rosebrough N J, Farr AL and Randall RJ. (1951). Protein measurement with the Folin phenol reagent. *J. Biol. Chem*, 193, 265-275.
22. Amerine MA, Pangborn RM and Rossler EB. (1980). Principles of sensory evaluation of food. Academic Press, New York.
23. Van Soest PJ. (1963). Use of detergents in analysis of fibrous feed II. A rapid method for determination of fiber and lignin. *J. Asso. Official Agril. Chem*, 46, 829-835.
24. Van Soest PJ, Vane RN and Moore LA. (1967). Estimation of true digestibility of forages by *in-vitro* digestion of cell wall Xth International Cong, 438.
25. Panse VS, Sukhatme PV. (1967). Statistical Methods for Agricultural Workers. Indian Council of Agricultural Research New Delhi, 70-72.