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Characterisation of sweet sorghum grain (*Seethani*)

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Abstract
Now-a-days, immature grains such as baby corn, *freekeh* have become a delicacy due to its appealing appearance and desirable texture. Along with these qualities, immature grains have better functionality too. This study was aimed at exploring the characteristics of immature sorghum grain locally known as *seethani* for its utilization. The results revealed that varietal differences were there for all the analyzed parameters including physical parameters, cooking quality, OAC, WAC, proximate composition, mineral content, sugar content and starch content characteristics. In terms of physical measurements, *seethani* was found to be smaller in size but it had a high amount ofprotein, dietary fiber, iron, and zinc. The functional properties of *seethani* differed from mature sorghum because of differences in starch content and composition. Therefore, this niche product can be popularized as baby corn and *freekeh*and can be explored for further bioactive functionality andits utility.

Keywords: *seethani*, physical parameters, functional properties, proximate composition, mineral, starch

1. Introduction
*Seethani*isan immature sorghum grain that is harvested during the milky stage with 50 to 60 percent moisture content and roasted before consumption[1]. This is a very popular seasonal ethnic food in some parts of North Karnataka and South Maharashtra. It is known by different names like *belasi*in North Karnataka, *hurda*in South Maharashtra and*ponk*in Gujarat. It is usually available only during cold winter months from November to February. The peak season is December and January. Advances in technology have made it available even in late October and early March.
Seethani can be prepared from any variety of sorghum but traditionally preferred specific varieties are *SakkariMukkari*, *Rao Saheb*, *Phule Madhur*, *Phule Uttara*, etc. In *SakkariMukkari* water content is higher and is sweet to taste like '*sakkari'*, *i.e*. sugar and there is a temptation to eat more and hence name '*mukkari*' meaning to gobble. The other landrace *Rao Saheb* seeds are used similar to *Sakkari Mukkari* [2]. There is a notion among elders that eating *seethani* for one month keeps the body healthier for a whole year [3]. Instead of this, it is limited to rural and poor people.
This special purpose sorghum,*seethani* can provide choice to the end users in food enterprises. There is a need to popularize *seethani* food as it is known that the immature grains have better nutritive quality than the mature grains because of the high fibre content (12 % to 20 % vs 10 % to 15 %), lowphytic acid, higher potassium/phosphorus ratio (>1),high fructo-oligosaccharides content which can be attributed to improved bioavailability of minerals such as iron, zinc; and reduction in blood pressure, anti-cancer and anti-diabetic properties etc[4, 5]. Now-a-day's agro-tourism business is increasing in the rural areas and supplying sorghum *seethani* as a niche productthat would get more profit to the farmers and producers. Systematic studies with respect to physical characteristics, cooking quality and chemical composition and value addition of *seethani* is needed. Therefore, the objective of the study was to characterize the physical characteristics, cooking quality and chemical composition of the *seethani*.

2. Material and methods
2.1. *Seethani* preparation
SMJ-1(sweet variety),KMJ-1(popping variety) and M35-1(chappati variety) were procured from K.V.K, Bijapur,Karnataka. The earheadswere harvested at 70 days and were processed traditionally into *seethani*by roasting panicles in a fire trench fuelled by cow dung for slow roasting. The roasted *seethani* grains were separated from panicles by rubbing with the hands when still hot and dried to a moisture level of 4±0.5%.

2.2 Physicochemical characteristics of *seethani*
The physical characteristics of *seethani viz.*, size of the grain, 1000 grain weight, 1000 grain volume, and bulk density were measured. Cooking parameters including cooking time [6],percent increase in weight after cooking, percent increase in volume after cooking, percent solids leached during cooking were measured with the functional properties *viz.* water absorption capacity [7] and oil absorption capacity [8] Chemical composition of *seethani*including proximate principles, dietary fiber, minerals, sugar and starch content of *seethani* of different varieties were analyzed in triplicate using standard AOAC procedures [9].

2.3 Statistical analysis
The SPSS version 16.0 software program was used to estimate the mean, standard deviation, standard error mean, and CD. One -way and two- way ANOVA was employed to know the sample differences.

3. Results& Discussion
3.1 Physical parameters
Sorghum takes 90 to 110 days to reach physiological maturity [10]. During maturation, physiological changes like

increase in size, pericarp thickening, decrease in moisture content, increase in starch content, etc takes place.If the grain is harvested before maturity, all of these parameters will get affected. Table 1 shows thephysical parameters of *seethani* of different sorghum varieties.

Length, breadth, and thickness of*seethani* ranged from 3.10 to 3.54, 3.47 to 4.19 and 1.79 to 2.31 respectively and 1000 grain weight ranged between 22.32 to 31.60g. Among all the varieties, KMJ-1 being a popping variety had the lowest measurement values for length, breadth, and thickness.Therefore, the least thousand grain weight and volume.The diameter of sorghum grain ranged from 3.32 to 3.8 mm, 1000 grain weight ranged from 30.14 g to 37.9g and 1000 grain volume 28.53 to 37.12ml and 0.77 to 0.81 g/ml bulk density [11, 12, 13].The physical parameters reported by these authors suggested that *seethani* is smaller than sorghum. Due toharvesting at the milky stage, the maturation process was hampered which resulted in smaller grain with low density. This incomplete growth can also beco-related with its starch accumulation and hence with cooking properties.

3.2 Cooking properties

Cooking properties include cooking time, increase in weight and volume, etc and are dependent on the structure of endosperm, starch content, pericarp thickness, and size and shape of the grain. In table 2 cooking properties of *seethani*are given. The popping variety is known to have hard pericarp and compactly packed endosperm which allows internal pressure and temperature to develop, enough for popping [14]. Table 2 suggests that the popping variety, KMJ-1 requires a longer time to cook which in turn permits more increase in volume. Due to the presence of hard pericarp, solid leached were least in the KMJ-1 *seethani.* Whereas solids leached were highest in SMJ-1 due to its high soluble sugar content. [15]Ali *et al.* (1983) reported the cooking time for sorghum ranged from 57 to 64 minutes. Longer cooking time for mature sorghum can beattributed to high starch content. Smallersize, underdeveloped starch content and thin pericarp of *seethani* may explain the differences in cooking properties with sorghum.Also *seethani* is a roasted grain i.e. it has been subjected to pre-treatment before cooking which might have damaged the starch which in turn shortened its cooking time. Therefore, shortened cooking time is better for from the processing point of view and hence can be better utilized.

Table 1: Physical parameters of *seethani* of different sorghum varieties

Variety	Length (mm)	Breadth (mm)	Thickness (mm)	Thousand grain weight (g)	Thousand grain volume (ml)	Bulk density (g/ml)
SMJ-1	3.22 ± 0.16^{b}	4.19 ± 0.14^{b}	1.92 ± 0.12^{b}	23.62 ± 0.42^{c}	25.23 ± 0.49^{c}	0.93 ± 0.01
KMJ-1	3.10 ± 0.27^{b}	3.47 ± 0.50^{a}	1.79 ± 0.15^{b}	19.87 ± 0.12^{b}	22.32 ± 1.50^{b}	0.89 ± 0.05
M35-1	3.54 ± 0.25^{a}	3.89 ± 0.29^{a}	2.31 ± 0.26^{a}	29.96 ± 2.01^{a}	31.60 ± 1.50^{a}	0.66 ± 0.27
F value	9.17	1.31	0.74	54.84	67.47	0.77
S.Em.±	0.07	0.10	0.06	0.68	0.72	0.16
C.D. @ 5 %	0.21^{*}	0.31^{*}	0.17^{*}	2.38*	2.52^{*}	NS

*Significant @ 0.05 level, NS- Non-significant

Samples with same superscript in the same column are not significantly different @ 0.05 level

Table 2: Cooking characteristics of *seethani* grains of different sorghum varieties

Variety	Cooking properties of grain			
	Cooking time (min)	Increase in weight after cooking (%)	Increase in volume after cooking (%)	Solid leached during cooking (%)
SMJ-1	10.00 ± 0.36^{b}	127.39 ± 2.18^{b}	106.96 ± 14.78^{a}	4.40 ± 0.31^{c}
KMJ-1	30.04 ± 0.56^{a}	126.19 ± 2.33^{b}	135.11 ± 8.36^{a}	2.12 ± 0.05^{b}
M35-1	27.69 ± 5.31^{a}	128.06 ± 7.13^{a}	121.85 ± 39^{a}	3.39 ± 0.29^{a}
F value	209.69	2.81	14.84	23.01
S.Em.±	1.78	1.60	4.22	0.14
C.D. @ 5%	6.17^{*}	3.02^{*}	14.92^{*}	0.50^{*}

*Significant @ 0.05 level, NS- Non-significant

Samples with the same superscript in the same column are not significantly different @ 0.05 level

3.2 Functional properties

Functional properties reflect the complex interaction between the composition, structure, molecular conformation and physicochemical properties of food components together with the nature of the environment in which these are associated and measured [16, 17, 18]. Functional properties of *seethani* flour such as water absorption and oil absorption are presented in table 3. WAC and OAC define the utilization of food/ food ingredients in the food industry. WAC and OAC of *seethani*flourwere found to be 200 to 276.66 percent and 155.9 to 161.3 %where SMJ-1 had the lowest WAC and highest OAC. For sorghum, WAC and OAC have been reported to range upto 131.34% and 90.56% [19].

Processing modifies the grain and may affect its functional properties too.*Seethani* is a processed grain with a higher level of lysine and lower levels of hydrophobic amino acids viz., proline and leucine than mature sorghum which may explain its high WAC[20]. [21]Eltayeb*et al.* (2011) suggestedthat the increase in WAC can also be attributed to the starch gelatinization and swelling of crude fiber during the heating process. For OAC the major chemical component affecting is protein. During *seethani*processing, denaturation of protein results inexposure of hydrophobic groups, having superior binding to hydrocarbon chains of

lipids [22]. Our result claims that this is a unique grain with high WAC and OAC which can be utilized in bakery very efficiently.

Table 3: Functional properties of *seethani* flour of different sorghum varieties

Variety	Water absorption capacity (%)	Oil absorption capacity (%)
SMJ-1	200.00±10.00^{b}	161.3 ±0.01
KMJ-1	276.66 ± 5.77^{a}	159.8 ± 0.04
M35-1	265.00 ± 5.00^{a}	155.9 ± 0.07
F value	66.12	74
S.Em. ±	4.19	2.78
C.D. @ 5 %	17.51*	NS

*Significant @ 0.05 level, NS: Non-significant

Samples with the same superscript in the same column are not significantly different @ 0.05 level

Table 4: Proximate composition of *seethani* of different sorghum varieties per 100 g

Variety	Moisture (%)	Crude Fat (g)	Ash (g)	Crude protein (g)	Total CHO (g)	Crude fibre (g)	Available CHO (g)	Energy (kcal)
SMJ-1	4.26 ± 0.13^{a}	2.80 ± 0.15^{b}	1.48 ± 0.05^{a}	12.25 ± 0.47^{a}	79.17 ± 0.54^{b}	2.82 ± 0.12^{a}	76.35 ± 0.67^{b}	392.33 ± 0.58^{a}
KMJ-1	4.46 ± 0.11^{a}	2.47 ± 0.04^{a}	1.46 ± 0.03^{a}	12.35 ± 0.33^{a}	79.24 ± 0.36^{b}	2.81 ± 0.05^{a}	76.43 ± 0.31^{b}	386.33 ± 3.78^{b}
M35-1	4.28 ± 0.05^{a}	2.63 ± 0.03^{b}	1.40 ± 0.04^{a}	9.22 ± 0.24^{b}	82.46 ± 0.29^{a}	2.28 ± 0.51^{a}	80.18 ± 0.42^{a}	389.59 ± 0.52^{ab}
F value	3.37	11.05	2.14	72.58	60.51	3.09	59.60	5.43
S.Em. ±	0.06	0.05	0.03	0.21	0.24	0.17	0.28	1.28
C.D. @ 5%	NS	0.18*	NS	0.72*	0.83*	NS	0.98*	4.45*

*Significant @ 0.05 level, NS: Non-significant

Samples with same superscript in the same column are not significantly different @ 0.05 level

Proximate composition of the food tells about its nutritive quality. Table 4 shows the proximate composition of *seethani.* Results showed significant differences in crude fat, crude protein, total carbohydrates, available carbohydrates and energy among varieties. [1]Thakre *et al*. (1981) studied the immature form of 16 varieties of sorghum and found similar results where protein content ranged from 9.72 to 14.81%, fat content ranged from 4.70 to 2.20% and ash content ranged from 1.60 to 2.70%.In comparison to the harvesting stage, immature sorghumcontains more protein[23]. In contrast to this,[24]Avramenko *et al*. (2016)found that immature wheat had less protein (9.8%) than mature wheat (13.4%). The difference in the protein synthesis and accumulation rate of different grains might be the reason for these non-congruent outcomes. Surprisingly, [25] Takruri *et al*. (1990) proved that the protein quality of milky stage grain is better than the dough stage or harvesting stage grain. Therefore, it can be concluded that the *seethani* is having better nutritive quality than sorghum in discussed aspects.

Table 5 suggests*seethani* as a good source of dietary fiber. Among all the varieties, SMJ-1 found to have highest amount of total dietary fiber whereas no significant difference was found in soluble and insoluble fiber. During the filling stage, the glucose unit polymerizes to form starch. In the case of *seethani*, polymerization of glucose was hampered in between this gave rise to monosaccharides, disaccharides and may be oligosaccharides, etc. As [26] Casiraghi *et al*. (2013) found immature wheat, *freekeh*, asa good source of indigestible fructo-oligosaccharide similarly, *seethani* can be explored for its functional fiber fraction.

Table 5: Dietary fibre content in *seethani* of different sorghum varieties per 100 g

Variety	IDF (g)	SDF (g)	TDF (g)
SMJ-1	10.02 ± 0.90^{a}	2.04 ± 0.20^{a}	12.06 ± 0.90^{a}
KMJ-1	8.89 ± 0.86^{a}	2.06 ± 0.74^{a}	10.96 ± 0.13^{ab}
M35-1	8.53 ± 0.30^{a}	1.47 ± 0.20^{a}	10.01 ± 0.13^{b}
F value	3.29	0.28	0.02
S.Em. ±	0.42	0.26	0.34
C.D. @ 5 %	NS	NS	1.19*

*Significant @ 0.05 level, NS: Non-significant

Samples with the same superscript in the same column are not significantly different @ 0.05 level

Table 6: Mineral content in *seethani* of different sorghum varieties per 100 g

Variety	Iron (mg)	Zinc (mg)	Calcium (mg)	Magnesium (mg)
SMJ-1	8.11 ± 0.06^{b}	2.76 ± 0.01	35.30 ± 0.43^{a}	126.83 ± 0.28^{b}
KMJ-1	4.40 ± 0.05^{c}	1.85 ± 0.00	31.60 ± 0.51^{b}	142.00 ± 0.00^{a}
M35-1	7.09 ± 0.00^{a}	2.24 ± 0.01	29.64 ± 0.16^{c}	123.50 ± 0.57^{c}
F value	248.13	2.82	54.11	2.91
S.Em.±	0.59	0.27	0.36	1.83
C.D. @ 5%	2.04*	NS	1.24*	9.32*

*Significant @ 0.05 level, NS: Non-significant

Samples with same superscript in the same column are not significantly different @ 0.05 level

The mineral content of anycropdependsupon the soil and geographical condition. Table 6 suggestedthat all varietiesdiffersignificantly in terms of mineral content includingiron, zinc, calcium, and magnesium. SMJ-1 varietyhad the highest content of iron, zinc, and calcium whereas KMJ-1 had the highestamount of magnesium. Similarresultswere found by Sajjanar*et al.* (2012)[27]where SMJ-1 and RSJ-1 reported having a higher content of micronutrients (zinc and iron) compared to M 35-1. *SakkariMukkari* (*seethani*variety) was recorded to have 8.18mg and 2.35mg of iron and zinc which was in agreement with our study [28].

Table 7: Sugar content in *seethani* of different sorghum varieties

Variety	Reducing sugar (%)	Non- reducing sugar (%)	Total sugar (%)
SMJ-1	2.63 ± 0.42	1.01 ± 0.35	3.65 ± 0.25^{a}
KMJ-1	2.11 ± 0.33	0.82 ± 0.28	2.92 ± 0.10^{b}
M35-1	1.92 ± 0.31	0.92 ± 0.17	2.85 ± 0.14^{b}
F value	2.61	0.92	15.79
S.Em. ±	0.21	0.17	0.10
C.D. @ 5 %	NS	NS	0.38*

*Significant @ 0.05 level, NS: Non-significant

Samples with the same superscript in the same column are not significantly different @ 0.05 level

All monosaccharidesare reducing sugars, containing aldehyde and ketone, whereas disaccharides such as sucrose are non-reducing sugars without any free hydroxyl group. Both mono and disaccharides are responsible for the sweetness of the grain. In table 7, we found out that SMJ-1 variety is the sweetest among all. SMJ-1 being the landrace cultivated for *seethani* purpose is having the highest amount of total sugars as well as reducing sugars.Thakre *et al*. (1981) [1] estimated water-soluble carbohydrates in milky stage sorghum which ranged from 1.05 to 2.6%. The total sugar content of twenty-two studied *seethani* purpose genotypesranged from 0.53 to 5.09% in the study of Chawan *et al*., 2013 [29]. During maturation of grain, enzymes namely α-D-glucose 1- phosphate (G1P), Uridinediphosphate α -D-glucose (UDPGIc), adenosine diphosphate α - D-glucose (ADPGlc); starch synthases are involved in the synthesis of starch from activated α – D-glucose.All these enzymes get activated after filling stage. That is why in mature sorghum the total sugars ranged from 1.51 to 2.11%, reducing sugars and non-reducing sugars content ranged from 0.11 to 0.15 and 1.37 to 1.99% [30]. On the contrary, the activation of these enzymes polymerizes sugars into starch. J. Ni. *et al*., (2011) [31]studied dynamic changes in sugar and starch content in wheat during the grain filling stage.This study revealed that the total soluble sugar, sucrose, fructan content decreased and pentosan, starch content and starch accumulation rate increased during the grain filling stage. Our study revealed that the starch and itsconstituents were significantly higher in mature sorghum grain than in *seethani.*

Table 8: Comparison of starch content and its components in *seethani* and mature grain

Stage	*Seethani* (g/100 g)			Mature grain (g/100 g)		
	Amylose	Amylopectin	Starch	Amylose	Amylopectin	Starch
SMJ-1	9.63 ± 0.55^{b}	35.01 ± 0.80^{a}	44.64 ± 0.54^{a}	26.53 ± 1.85^{c}	46.31 ± 2.01^{a}	72.85 ± 0.62^{b}
KMJ-1	22.66 ± 0.57^{a}	14.11 ± 1.04^{c}	36.77 ± 0.59^{c}	47.6 ± 0.52^{a}	23.54 ± 0.69^{c}	71.14 ± 0.34^{c}
M35-1	10.83 ± 0.15^{ab}	26.39 ± 9.48^{b}	40.89 ± 0.62^{b}	33.43 ± 0.40^{b}	41.77 ± 0.73^{b}	75.06 ± 1.81^{a}
	F- value		S.Em. ±		C.D. @ 5%	
Variety	626.91*		4.48		4.33*	
Stage	2.73^{NS}		5.85		27.26*	
Variety*Stage	33.73*		3.06		870.46*	

*Significant @ 0.05 level, NS: Non-significant

Samples with the same superscript in the same column are not significantly different @ 0.05 level

4. Conclusion

Seethani is roasted immature sorghum which is consumed only in the areas of north Karnataka and south Maharashtra. Researches on immature grains including wheat i.e. *freekeh* and maize i.e. baby corn showed that immature grains are a better source of oligomers and nutrients which are easily digestible. Similarly, in this study, we tried to characterize the immature sorghum i.e. *seethani*.Our study showed that *seethani* can be a good source of nutrients including protein, dietary fiber both soluble and insoluble, minerals such as iron, zinc and has different functional properties than its mature counterpart. Hence, the utilization of *seethani* as food depends on its functional properties therefore, it needs to be explored in depth.

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6. References

1. Thakre SK. Nutritive values of some *hurda* varieties of sorghum. J Maharashtra Agril. Univ. 1981; 6 (1):61-62.
2. Hemalatha S, Sajjannar G, Biradar B. Traditional sorghum landrace for specific food preparations. Paper presented during National Conference on “traditional knowledge systems, intellectual property rights and their relevance for sustainable development” held during 24- 26 November 2008 at Natioal Institute of Science Communication and Information Resources (NISCAR), New Delhi, 2008, 58.
3. Sajjanar GM, Patil PB, Biradar BD, Hemalatha S, *et al*. Special Sorghum Varieties of North Karnataka for Traditional and Novel Foods, Value Addition and Entrepreneurship Development, National Research Centre for Sorghum, Rajendranagar. Hyderabad, and All India Co-ordinated Sorghum Improvement Project,

Regional Agricultural Research Station Bijapur, 586-101, Karnataka, 2009, 15-23.
4. Abecassis J, Bouniol A, Chaurand M. Method for obtaining monocotyledon plant grains for human or animal food. US2009/0226594 A1, 2008.
5. Paradiso A, Cecchini C, De Gara L, D'Egidio MG. Functional, antioxidant and rheological properties of meal from immature durum wheat. Journal of Cereal Science. 2005; 43:216-222
6. Sareepuang K, Siriamornpun S, Wiset L, Meeso N. Effect of soaking temperature on physical, chemical and cooking properties of parboiled fragrant rice. World J. Agric Sci. 2008; 4(4):409-415.
7. Quin JR, Paton D. A practical measurement of water hydration capacity of protein materials. *Cereal Chem.* 1983; 56:38-44.
8. Sosulski FW, Humbert ES, Bui K, Jones JO. Functional properties of rapeseed flour concentrates and isolates. J. Food Sci. 1976;, 41:1348-1354.
9. AOAC. Official methods of analysis of AOAC International (17th ed.). Gaitherburg. AOAC International Inc., USA, 2000.
10. Wani SP, Albrizio VR, Rao N. Sorghum. In: Crop Yield response to Water: FAO Irrigation and Drainage Paper 66, (Eds. Pasquale Steduto, Theodore C. Hsiao, Elias Fereres and Dirk Raes).Pages. 144-153. FOOD AND AGRICULTURE ORGANIZATION of UN, Rome, 2012.
11. Simonyan KJ, El Okene AM, Yiljep YD. Some Physical Properties of Samaru Sorghum 17. Agril. Engg. Int. 2007; 9:1-15.
12. Gaul JA, Raya Duarte P. Effect of moisture content and tempering method on the functional and sensory properties of popped sorghum. Cereal Chem. 2008; 85(3):344-350.
13. Reddy M. Influence of process variables and flour characteristics of sorghum cultivars on rheological properties of dough and roti. M.H.Sc. Thesis, Univ. Agric. Sci., Dharwad (India), 2000.
14. Cretors C. Popcorn Products. In: "Snack Foods Processing", (Eds.): Lusas, E. W. and Rooney, L. W..Technomic Publishing, Lancaster, USA, 2001, 385-420
15. Ali MR, Wills RBH. Milling and cooking of hybrid sorghum grains. Plant Food Hum. Nutr. 1983; 32(1):59.
16. Kinsella JE. functional properties of proteins in foods. Critical reviews in food science and nutrition. 1976; 1(3):219-280.
17. Kaur M, Singh N. Relationships between selected properties of seeds, flours, and starches from different chickpea cultivars. Int. J Food Prop. 2006; 9:597-608.
18. Siddiq M, Nasir M, Ravi R, Dolan KD, Butt MS. Effect of defatted maize germ addition on the functional and textural properties of wheat flour. Int. J. Food Prop. 2009; 12:860-870
19. Elkhaifa AEO, Bernhardt R. Influence of grain germination on functional properties of sorghum flour. Food Chem. 2009; 121(2):387-392.
20. Deyoe CW, Shoup FK, Miller GD, Bathurst J, *et al*. Amino acid composition and energy value of immature sorghum grains. Cereal Chem. 1970; 47:363-368.
21. Eltayeb AR S, Ali AO, Abou Arab AA, Abu Salem FM. Chemical composition and Functional properties of flour and protein isolate extracted from bambara groundnut (*Vigna subterranean*). African J. of Food Sci. 2011; 5(2):82-90.
22. Oladele A, Aina J. Chemical composition and functional properties of flour produced from two varieties of tigernut (Cypernus esculentus). African Journal of Biotechnology. 2007; 6:2473-2476.
23. Thakre SK. Agrosro report on chemistry of sorghum, Punjabaro Krishi Vidyapeeth Akola (India), 1978.
24. Avramenko N P, Karklina D, Gedrovica I. Investigation of immature wheat grain chemical composition. Res. Rural Develop. 2016; 1:102-105.
25. Takruri HR, Humeid MA, Umari MAH. Protein quality of parched immature durum wheat (*Freekeh*). J. Sci. Food Agri. 1990; 50(3):319-327.
26. Casiraghi MC, Pagani MA, Erba D, Marti A, Cecchini C, *et al*. Quality and nutritional properties of pasta products enriched with immature wheat grain. Int. J. Food Sci. Nutri. 2013; 64(5):544-550.
27. Sajjanar GM, Biradar BD, Patil P. Testing*hurda*varieties of north Karnataka for tender and processed grains in sorghum. *Proc. National Seminar on Millets*, 12thNovemeber, Hyderabad, 2012, 132.
28. Reddy AK, Sajjanar GM, *et al*. Genetic analysis of shoot fly resistance, drought resistance and grain quality component traits in *rabi* sorghum (*Sorghum bicolor* (L.) Moench), *M.Sc Thesis*, University of Agriculture Science Dharwad, Karnataka, 2012.
29. Chavan UD, Dalvi US, Pawar GH, Shinde MS. Selection of genotype and development of technology for sorghum hurda production. Int. Food Res. J. 2013; 20(3):21379-1382.
30. Reddy M. Influence of process variables and flour characteristics of sorghum cultivars on rheological properties of dough and *roti*. *M.H.Sc. Thesis*, Univ. Agric. Sci., Dharwad (India), 2000.
31. J NI B FENG, Z XU, T WANG. Dynamic Changes of Wheat Quality during Grain Filling in Waxy Wheat WX12, Czech J. Genet. Plant Breed., 47, 2011 (Special Issue): S182–S185, 2011.