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Acceptable qualities of black soybean genotypes (*Glycine max*)

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Abstract
A total of three soybean genotypes including two black soybeans-kalitur and DSM (Dharwad Soybean Mutant) with one yellow soybean - DSb 21 were procured from Department of Crop Physiology, University of Agriculture Sciences, Dharwad during kharif - 2017. The cooking quality of grains was evaluated in terms of soaked weight and volume, cooked weight and volume, cooking time, per cent increase in weight and volume and per cent solids leached during boiling and pressure cooking methods. The acceptability of cooked seeds was evaluated for organoleptic profile by using 9 point hedonic scale. Among the cooking quality parameters, per cent increase in weight and cooking time differed significantly ($p > 0.01$) among boiled yellow and black soybean genotypes. Significant ($p > 0.01$) difference was noted in pressure cooking time of yellow and black soybean genotypes. Boiling of white or black resulted in increased weight (30 - 32.88 g %), increased volume (24 – 28 ml %) and time took 1-11/2 hrs for cooking was with acceptable index of 83.88. However pressure cooking of black soybeans resulted in higher increase in weight (32 - 39.77 g %), volume (27- 29.50 ml %) and took less time for cooking of seeds (20 - 31 min). The acceptable index of pressure cooked seeds was 83 - 84.51.

Keywords: Black soybean, DSM, Kalitur, DSb 21

1. Introduction
Soybean (*Glycine max* L.) has a rich history and dates back nearly 5,000 years to their native East Asia. It is widely grown for its edible bean, which has numerous uses. The soybean (*Glycine max*) is a species of legume (family – *fabaceae*). The etymology of the genus *Glycine* comes from Linnaeus. The genus *Glycine* is divided into two subgenera, *Glycine* and *Soja* (https://en.mm.wikipedia.org>wiki>Soybean). Both species are annuals in which *Glycine soja* is the wild ancestor of *Glycine max* grown in China, Japan, Korea and Russia. Most commonly the black soybean was used historically and today is still used to produce the famous Chinese flavoring ingredient- fermented black soybeans.

Soybean protein and soybean oil content together account for 56 per cent of dry soybeans by weight (36 % protein and 20 % fat). The remainder consists of 30 per cent carbohydrates, nine per cent water and five per cent ash. Soybeans comprise approximately eight per cent seed coat or hull, 90 per cent cotyledons and two per cent hypocotyls axis or germ. The soybean includes other nutrients and non-nutrients such as saponins, phytates, protease inhibitors, phenolic acids, lecithin, phytosterols, isoflavones and omega-3 fatty acids.

In addition to these compounds, black soybean has unique properties owing to its black hull which is different from yellow soybean and green soybean. The black hull contains various polyphenols such as anthocyanins, pro cyanidins and catechins. Black seed coat of soybeans have been found to contain high contents of tocopherol, isoflavones and flavonoids which possess biological activity (Correa *et al*. 2010; Jeng *et al*. 2010; Kumar *et al.* 2010) [3, 6-7]. Antioxidant properties such as ferric reducing antioxidant power, free radical-scavenging effect and total phenolics have shown to be comparatively high in black soybean in the yellow soybean (Xu *et al.* 2007; Xu and Chang, 2008; Kumar *et al*. 2010) [14, 137]. In addition, the greater inhibition of low density lipoprotein oxidation has been recorded in black soybeans over that of yellow soybeans (Takahashi *et al.* 2005) [11]. Kumar *et al.* (2010) [7] indicated that yellow, green and black soybean seeds had similar contents of total phenolics and isoflavones.

The relationship between soybean intake and human health has been widely investigated due to the nutritional characteristics of this grain. Numerous studies have been performed on the nutritional and functional value of genetically improved soybean with different seed coat colors, standing out the black soybeans.

They are associated with a wide range of health benefits such as anti-mutagenic effect, anti-inflammatory properties, reduction in synthesis of low-density lipoprotein and reduced effects of DNA damage (Astadi *et al.* 2009; Wang *et al.* 2010) [2, 12]. In India, Japan and Korea, black soybean has been widely consumed as a medicine for hundreds of years for detoxification and anti-inflammation and to improve the quality of red blood cells (Xu and Chang, 2008) [13], as it contains a variety of substances that contribute positively to human health, including isoflavones (Xu and Chang, 2008) [13].

In addition to the intensive use of soybean for the production of oil and meal, there has been an increased use of water soluble soybean extract or soy milk. The soybean market has been growing markedly in recent years (93 %), especially in the beverage segment and the ready-to-drink juice market has grown (25 %) in the same period due to consumer demand for healthy and practical products. Thus, there has been a large production of soybean by-products derived from the manufacturing process of these grains. For human consumption, soybeans must be processed with heat to destroy the anti-nutrients as raw soybeans, including the immature green soybeans cause digestive problems to all monogastric animals (https://en.mm.wikipedia.org>wiki>Soybean).

Traditionally in China, black soybeans have been reported to prepare *Bacillus*-fermented soybeans - *chungkukjang*. The traditional Chinese medicine theory believes that black soybean has been used as a component in ancient medicines to treat diabetes, hypertension, anti-aging, cosmetology and black-hair and so on. Black soybean containing herbal prescriptions can increase the number of circulating yellow blood cells in leukopenia patients. Black soybean has been used as an herbal medicine to treat jaundice and edema. It has also been used to treat enuresis by affecting the functions of the kidney and spleen. The hull of the black soybean has been used for the treatment of vertigo and headache as well as for detoxification and diuresis. Exploring the health benefits of black soybean, the research study on, to study the cooking quality and acceptability of the black soybean.

2. Materials and Method

2.1 Procurement of soybean

A total of three soybean genotypes including two black soybeans - Kalitur and DSM (Dharwad Soybean Mutant) with one yellow soybean - DSb 21 were procured from Department of Crop Physiology, University of Agriculture Sciences, Dharwad during *Kharif* - 2017.

2.2 Cooking quality and acceptability of soybean

Since preliminary studies revealed that soaking soybean seeds overnight (8 hrs) did not imbibe water completely in the grains, the soaking time was extended and further optimized. About 20 g of black and yellow soybean seeds were soaked for 18 hrs, drained and subjected for boiling and pressure cooking. The cooking quality of grains was evaluated in terms of soaked weight and volume, cooked weight and volume, cooking time, per cent increase in weight and volume and per cent solids leached. The acceptability of cooked seeds was evaluated for organoleptic profile using 9 point hedonic scale by semi trained panelists (Amerine *et al*., 1965) [1].

2.3 Statistical analysis

The SPSS version of 16 software programmer was used to estimate the mean, standard deviation, standard error of mean, 'S. E difference., 'CD', 'F' value. One way ANOVA was employed to know the difference between the genotypes and recipes (Fisher and Yuest, 1963) [4]. The critical difference was tested at 1 and 5 per cent significance level.

3. Result and Discussion

3.1 Cooking quality and acceptability of soybean

Cooking quality of seeds including cooking time, per cent increase in weight, per cent increase in volume and per cent solids leached of boiled soybean genotypes are given in Table 1.

The per cent increase in weight and cooking time among soybean genotypes varied significantly ($p \geq 0.01$). The percent increase in weight ranged between 30.73 - 32.88. The highest increase in weight was found in DSM black soybean (32.88 g) followed by Kalitur (31.19 g) and least weight grain was seen in DSb 21 (30.73 g). The results were found to be statistically significant ($p \geq 0.01$). The per cent increase in volume varied between 24.68 - 28.00 ml. Kalitur had significantly ($p \geq 0.01$) highest (28.00 ml) per cent increase followed by DSM (26.39 ml) and least increase was seen in DSb 21 (24. 68 ml). Significant difference ($p \geq 0.01$) was evidenced in cooking time among the genotypes which ranged between 88 - 107 min. Least time for boiling was taken by Kalitur (88 min) followed by DSM (90 min) and highest boiling time was evidenced in DSb 21 yellow soybean (107 min). The per cent solids leached ranged between 0.06 - 0.09 with highest in Kalitur (0.09) followed by DSM (0.07) and DSb 21 (0.06).

Table 2 depicts the sensory scores of boiled soybean genotypes. The appearance scores ranged between 7.29 - 7.60 with highest scores for appearance for DSb 21 (7.60). The DSb 21, Kalitur and DSM genotypes had colour scores (7.50, 7.23, 7.65), flavor scores (7.35, 7.26, 7.60), taste scores (7.00, 7.32, 7.45), texture scores (6.8, 7.05, 7.50) and overall acceptability scores (7.23, 7.05, 7.55) did not differ significantly. The boiled DSM black soybean seeds had highest sensory scores for colour (7.65), flavor (7.60), taste (7.45), texture (7.50) and overall acceptability (7.50).

Cooking quality of pressure cooked seeds are given in Table 3. The per cent increase in weight and cooking time of soybean genotypes did not vary significantly among the black soybean genotypes. The maximum per cent increase in weight was found in DSM (32.88 g) followed by Kalitur black soybean (31.19 g) and per cent increase in weight was found to be least in DSb 21 (32.39 g). The cooking time among genotypes ranged between 20 - 31 min. DSM black soybean was cooked in short duration (20.50 min) followed by Kalitur (21.00 min) and highest time for pressure cooking was taken by DSb 21 (31.50 min). The per cent increase in volume varied between 27.00 - 29.50 ml. The highest increase in volume was noted for Kalitur black soybean (29.50 ml) followed by DSM (27.50 ml) with least for DSb 21 (27.00 ml). The per cent solids leached out ranged between 0.08 - 0.09 with maximum in DSb 21 and Kalitur genotypes (0.09) and least in DSM (0.08). However results were found to be non-significant.

Table 4 depicts the sensory scores of pressure cooked soybean genotypes. Significant ($p \geq 0.01$) difference was evidenced in sensory scores of pressure cooked seeds of soybean genotypes. The soybean genotypes had appearance scores that ranged between 7. 36 to 7.90 with highest appearance scores for DSb 21- yellow soybean (7.90) followed by DSM - black soybean (7.76).

Table 1: Cooking quality of seeds of soybean genotypes on boiling

Genotypes	Weight (g)			Volume(ml)			Cooking time (min)	Leached out solids (%)
	Initial	After boiling	(%)	Initial volume	After boiling	(%)		
DSb 21	20	50.16 ± 1.17	30.73 ± 1.28	21.50 ± 0.71	46.18 ± 0.25	24.68 ± 0.95	107	0.06
Kalitur	20	51.20 ± 2.04	31.19 ± 2.04	20.00 ± 0.17	48.00 ± 1.41	28.00 ± 2.83	88	0.09
DSM	20	52.56 ± 0.81	32.88 ± 0.81	22.00 ± 0.00	48.50 ± 7.07	26.50 ± 0.71	90	0.07
Mean ± S.D	20	51.56 ± 1.53	31.60 ± 1.52	21.17 ± 1.17	74.55 ± 1.30	26.39 ± 2.02	60	0.07
F – value		1.38	1.188	2.6	3.5	1.77	193.99	0.00
S. Em ±		0.12	1.04	0.65	0.65	1.25	2.42	0.02
CD @ 1% level		0.53	4.68**	NS	NS	NS	10.87**	NS

DSb 21 - Yellow, Kalitur and DSM – black

Note: Mean ± S.D; CD - Critical Difference; S. E m ± Standard Error of mean; NS- Non- Significant; ** Significant at 0.01 per cent level
Different super script within a column indicate significant difference at 0.05 level by DMRT

Table 2: Sensory profile of boiled seeds of soybean genotypes

Genotypes	Appearance	Colour	Flavor	Taste	Texture	Overall acceptability	Acceptability index
DSb 21	7.60 ± 1.09	7.50 ± 1.05	7.35 ± 0.81	7.00 ± 0.91	6.8 ± 1.15	7.23 ± 1.05	80.51
Kalitur	7.29 ± 0.84	7.23 ± 0.83	7.26 ± 0.75	7.32 ± 0.98	7.05 ± 0.96	7.05 ± 0.74	80.00
DSM	7.55 ± 0.78	7.65 ± 0.81	7.60 ± 1.14	7.45 ± 1.43	7.50 ± 1.13	7.55 ± 1.09	83.88
Mean	7.48	7.46	7.40	7.25	7.11	7.27	
F-value	1.04	0.97	0.67	0.82	2.01	1.23	
S. Em ±	0.65	0.64	0.65	0.81	0.79	0.7	
CD @ % level	NS	NS	NS	NS	NS	NS	

DSb 21 - Yellow, Kalitur and DSM – black

Note: Mean ± S.D; CD - Critical Difference; S. E m ± : Standard Error of mean; NS- Non - Significant

Table 3: Cooking quality of seeds of soybean genotypes on pressure cooking

Genotypes	Wight (g)			Volume (ml)			Cooking time (min)	Leached out solids
	Initial	After boiling	Per cent increase	Initial volume	After boiling	Per cent increase		
DSb 21	20	52.39 ± 0.66	32.39 ± 0.66	20.50 ± 0.71	47.50 ± 2.12	27.00 ± 2.82	31.50 ± 2.12	0.09 ± 0.01
Kalitur	20	51.60 ± 0.06	39.77 ± 0.66	19.00 ± 1.41	48.50 ± 2.12	29.50 ± 0.71	21.00 ± 1.40	0.09 ± 0.02
DSM	20	52.81 ± 0.66	32.81 ± 0.65	21.50 ± 1.41	49.00 ± 0.00	27.50 ± 0.71	20.50 ± 0.71	0.08 ± 0.04
Mean ± S.D	20	52.26 ± 0.75	34.99 ± 6.60	20.33 ± 1.37	48.33 ± 1.50	28.00 ± 1.79	24.33 ± 5.68	0.08 ± 0.02
F-value		1.78	0.68	3.16	0.39	1.17	33.07	0.08
S. Em ±		0.46	4.99	0.71	1.22	1.22	1.08	0
CD @ 1% level		NS	NS	NS	NS	NSs	4.86**	NS

DSb 21 - Yellow, Kalitur and DSM – black

Note: Mean ± S.D; CD - Critical Difference; S. E m ± Standard Error of mean; NS- Non - Significant; ** Significant at 0.01 percent level

Table 4: Sensory profile of pressure cooked of seeds of soybean genotypes

Genotypes	Appearance	Colour	Flavor	Taste	Texture	Overall acceptability	Acceptability index
DSb 21	7.90 ± 1.07	8.02 ± 0.89	7.85 ± 0.74	7.25 ± 0.85	7.2 ± 0.83	7.42 ± 0.81	84.51
Kalitur	7.40 ± 0.94	7.35 ± 0.23	7.60 ± 0.75	7.72 ± 0.78	7.42 ± 0.74	7.37 ± 0.74	83.07
DSM	7.76 ± 0.78	7.71 ± 0.78	7.71 ± 1.68	7.76 ± 1.44	7.71 ± 1.45	7.61 ± 1.42	83.74
Mean	7.68	7.69	7.72	7.57	7.44	7.46	
F-value	1.53	0.06	0.83	0.25	0.40	0.76	
S. Em ±	0.64	0.62	0.72	0.77	0.75	0.74	
CD @ 1% level	NS	1.75*	NS	NS	NS	NS	

DSb 21 - Yellow, Kalitur and DSM – black

Note: Mean ± S.D; CD - Critical Difference; S. E m ± Standard error of mean; NS - Non Significant; * Significant difference at 0.05 per cent level

The colour scores were found to be 8.02, 7.35 and 7.71 for DSb 21, Kalitur and DSM genotypes with highest colour scores for DSb 21 (8.02) followed by DSM (7.71). The flavor scores of cooked seeds varied between 7.6 to 7.85. Flavor scores of cooked DSb 21 (7.85) scored maximum followed by DSM (7.71) and least flavor score was noted for Kalitur (7.60). The taste sores of pressure cooked soybean seeds were 7.25, 7.72 and 7.76 for DSb 21, Kalitur and DSM respectively. The highest taste score was noted in DSM (7.76) followed by Kalitur (7.72). The textural scores of pressure cooked seeds were 7.20, 7.42 and 7.71 for DSb 21, Kalitur and DSM respectively. Texture of pressure cooked black soybean seeds were more acceptable which was noted in DSM (7.71) and Kalitur (7.42) compared to DSb 21(7.20). The overall acceptability scores of pressure cooked seeds ranged between 7.37 to 7.61. The genotype DSM (7.61) had higher overall acceptability scores followed by Kalitur (7.37) and DSb 21 (7.42). DSM black soybean had highest acceptability index (83.74) followed by DSb 21 (84.51) and least was found in Kalitur (83.07). However there was no significant difference evidenced among the sensory scores for yellow and black soybean varieties.

The black soybean whole grains had better nutritional profile, cooking quality and acceptability which was on par with that of yellow soybean.

4. Discussion

The cooking quality of soybean varieties was tested in terms

of boiling and pressure cooking methods. The cooking quality parameters included per cent increase in weight, volume, cooking time and per cent solids leached. Among the cooking quality parameters, per cent increase in weight and cooking time differed significantly ($p \geq 0.01$) among boiled yellow and black soybean genotypes. Significant ($p \geq 0.01$) difference was noted in pressure cooking time of yellow and black soybean genotypes. Though the seed coat was thick in DSM, the functional properties in terms of hydration capacity and swelling capacity were noted to be higher in DSM black soybean genotype which might have lowered the boiling time (90 min) and pressure cooking time (21 min) compared to yellow soybean - DSb 21 (107 min and 31 min). Yellow soybeans in the present study were found to be hard compared to black soybean and thus cooked for longer duration in both boiling and pressure cooking methods. The results reported for cooking time (31 min) of yellow soybean in the present study is higher than those reported by Shridara *et al.,* (1997) [10]. Sharma *et al.,* (2004) [9] reported similar results w.r.t. cooking time of seeds with increase in cooked volume. Minimum cooking time was noted for seeds soaked in distilled water (65 min), 1 per cent citric acid (55 min) and 2 per cent sodium bi carbonate (20 min) respectively (Sharma *et al.,* 2013) [8]. Soaking increases the physical characteristics due to the imbibition. Further boiling soaked seeds in distilled water for 30 min resulted in increased in weight, volume and per cent solid leached out in the present study.

Sensory evaluation of cooked soybean genotypes - boiling and pressure cooking revealed that the cooked grains of yellow and black soybean genotypes had similar sensory scores ranging 7.00 - 7.65. The boiled DSb 21, Kalitur and DSM had similar appearance scores (7.60, 7.29, 7.55), colour scores (7.50, 7.23, 7.65), flavor scores (7.35, 7.26, 7.60), taste scores (7.00, 7.32, 7.45), texture scores (6.80, 7.05, 7.50) and overall acceptability scores (7.23, 7.05, 7.55) which did not differ significantly. The acceptability indices of cooked yellow and black soybean were found to be 80.51, 80.00 and 83.88 respectively indicating that boiled black soybean are on par with yellow soybean.

Except for colour scores, the pressure cooked seeds of both black and yellow soybean did not differ with respect to sensory scores *viz,* appearance, colour, flavor, taste, texture and overall acceptability. The pressure cooked seeds of DSb 21 had significantly ($p \geq 0.01$) higher colour scores (8.02) compared to black soybeans which might be due to its creamish yellow colour. The black colour of seed coat in DSM and Kalitur resulted in less colour scores.

5. Conclusion

The cooking quality of soybean revealed that soybean seeds took 88 - 107 min for boiling with least boiling time for blacks soybean genotypes (88 and 90 min). The per cent increase in weight and volume were highest in DSM (32 %) and Kalitur (28 %) respectively. Soybean genotypes took 20 - 31 min for pressure cooking with least cooking time for black soybean, DSM (20 min). The per cent increase in weight and volume of pressure cooked seeds ranged between 32-39 and 27 - 29 respectively. The black soybean genotypes took less time for boiling and pressure cooking. Cooking quality of DSM and Kalitur soybean genotypes were better than that of yellow soybean (DSb 21).

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