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Dhruvit D Dashlaniya
Dairy Technology
Department, SMC College of
Dairy Science, Kamdhenu
University, Anand, Gujarat,
India

Suneeta V Pinto
Dairy Technology
Department, SMC College of
Dairy Science, Kamdhenu
University, Anand, Gujarat,
India

Corresponding Author:
Dhruvit D Dashlaniya
Dairy Technology
Department, SMC College of
Dairy Science, Kamdhenu
University, Anand, Gujarat,
India

Impact of type of jaggery on quality attributes of pumpkin seed incorporated burfi

Dhruvit D Dashlaniya and Suneeta V Pinto

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Abstract

Burfi is an indigenous milk product made from khoa that is excellent in nutrition. Burfi contains various additives that boost its sensory appeal and customer acceptability. This study was conducted to select the type of jaggery to be used for manufacture of Pumpkin seed incorporated burfi. Three types of jaggery viz. sugarcane jaggery, palm jaggery and coconut jaggery were screened. Burfi samples containing 50% replacement of sugar with jaggery were prepared. Replacement of sugar with all the three types of jaggery significantly ($P < 0.05$) enhanced the moisture and ash content of the product and caused a significant ($P < 0.05$) decrease in carbohydrate, hardness, chewiness, gumminess and springiness of burfi while no significant ($P > 0.05$) effect was observed in case of protein and free fatty acid content. Replacement of sugar with all the three types of jaggery resulted in significant ($P < 0.05$) decrease in L^* value while a^* and b^* value significantly ($P < 0.05$) increased. Among the three types jaggery, palm jaggery was found to be the most acceptable based on sensory evaluation. Hence, palm jaggery is recommended for use as source of sweetener in pumpkin seed incorporated burfi.

Keywords: Burfi, Jaggery, Pumpkin seeds incorporated burfi (PSIB)

Introduction

Burfi is a popular milk-based confection in India and has the potential to gain global recognition. On average, 100 g of plain milk burfi provides approximately 400 to 450 kcal, containing around 7 to 10 g of protein, 20 to 25 g of fat (with a significant portion as saturated fat) and 45 to 50 g of carbohydrates, of which about 35 to 40 g are sugars. The incorporation of fruit seeds or seed powder in burfi production is becoming increasingly popular among consumers due to its unique flavor and enhanced nutritional value. Introducing such ingredients into burfi not only adds value to the product but also enriches it with essential nutrients. The development of such nutrient-rich dairy products align with the growing consumer demand for healthier and more functional food options (Sharma *et al.*, 2023) [13]. Pumpkin, belonging to the genus *Cucurbita* and the family *Cucurbitaceae*, is cultivated worldwide for various purposes, including food, animal feed and decoration. Utilizing pumpkin seeds is expected not only to add value to production but also can aid in developing new food products.

Refined sugar is commonly used as a sweetener in burfi preparation. However, while it enhances sweetness, excessive consumption is linked to various health issues, including obesity, dental cavities, diabetes, hypertension, hyperglycaemia and heart disease. Growing awareness of these health risks has led consumers to seek healthier alternatives to sucrose-based products. And also, to compensate these sugar problems, use of other healthy sweeteners can be a solution. As a result, jaggery is gaining popularity due to its perceived higher nutritional value compared to refined white sugar.

India is the largest producer and consumer of jaggery, accounting for over 70% of global production (Pravallika *et al.*, 2018) [11]. Compared to refined sugar, jaggery is considered a more wholesome alternative. It contains 65 to 85% sucrose, whereas refined sugar consists of approximately 99.5% sucrose. Additionally, jaggery has a higher mineral content, ranging from 0.6% to 1.0%, while sugar contains only about 0.05% minerals (Singh, 2007) [14]. Research has also highlighted the pharmacological benefits of jaggery (Nayaka *et al.*, 2009) [9]. Rich in proteins, vitamins and essential minerals like iron and copper, jaggery serves as a natural energy booster. It is known for its therapeutic properties, aiding in blood purification,

supporting liver function and promoting overall health. Furthermore, it improves digestion, detoxifies the liver, relieves constipation and enhances energy levels. Jaggery also possesses anti-toxic and anti-carcinogenic properties and is used in managing stress, bronchial infections and premenstrual syndrome (Hirpara *et al.*, 2020) [6]. Based on the source, jaggery is primarily made from sugarcane (*Saccharum officinarum* L.) and the sap of various palm species such as date palm (*Phoenix dactylifera* L.), palmyra palm (*Borassus flabellifer* L.), sago palm (*Caryota urens* L.), and coconut palm (*Cocos nucifera* L.) (Pattnayak and Misra, 2004) [10]. Replacing cane sugar with jaggery in dairy ingredients is expected to enhance its depth and imparts a distinct, caramel-like flavour. The rich, unique taste of jaggery can impart a pleasing golden-brown colour which may improve its natural and appealing appearance. Consumers today are increasingly aware of the health implications of their diet and prefer dairy products that are not only delicious but also nutritionally enhanced. The integration of natural ingredients such as pumpkin seeds and jaggery into burfi presents an opportunity to enhance the protein, mineral, fiber and antioxidant content of burfi; reduce dependency on refined sugar by using a natural sweetener, improve the sensory appeal of burfi and develop a functional dairy sweet with health-promoting properties. Despite the commercial success of traditional burfi varieties, limited research has been conducted on replacement of sugar with jaggery in pumpkin seed incorporated burfi. The development of such a product could cater to the growing demand for healthier dairy-based sweets while utilizing locally available, cost-effective ingredients, keeping in view the above facts, this investigation has been planned to select the type of jaggery for preparation of pumpkin seed incorporated burfi.

Materials and Methods

Fresh, raw mixed (cow and buffalo) whole milk received at Anubhav Dairy; Anand was used as the base material for manufacture of burfi. Pumpkin seeds of “True elements” brand, HW wellness solutions Pvt. Ltd. Maharashtra were used. Cane sugar of “Madhur” Shree Renuka sugars Ltd; Mumbai brand of commercial grade (M grade) was used. Tata salt, Tata chemicals Ltd., Gujarat was used. Sugarcane jaggery of organic tattva, Mehrotra consumer products Pvt. Ltd., Greater Noida was used. Palm jaggery of Urban platter palm jaggery, Istore direct trading Pvt. Ltd., Mumbai was used. Coconut jaggery of urban platter, Istore direct trading Pvt. Ltd., Mumbai was used.

Preparation of burfi: Burfi was prepared from milk standardized to (6.0% milk fat and 9.0% MSNF). Dry salt roasted (85 to 90 °C/15 min) pumpkin seeds were incorporated @ 3.0% w/w of milk. Half of the dry salt roasted pumpkin seeds in the form of a paste were added after forewarming of milk (85 °C/10 min). The remaining half (coarsely cut pumpkin seeds) were added after pat formation. Sugar was added @ 6% w/w of milk. In all the three burfi samples sugar was replaced @ 50% with the three types of jaggery viz. J1, J2 and J3 respectively. Preliminary trials were taken to select the rate of replacement of sugar with jaggery. At higher levels of replacement, the samples were criticized for pronounced jaggery flavour and slight stickiness in the samples. C (control) was prepared using sugar @ 6.0% w/w of milk and

@ 3% dry salt roasted pumpkin seeds. The contents were heated in an open pan with continuous stirring. After the desired consistency was obtained the contents were whipped and worked on a low flame for 2 to 4 min. Thereafter, the contents were spread in a clean greased tray, moulded and allowed to set at room temperature for 10 to 12 h. Burfi was cut into square pieces (40 × 30 mm size, 25 mm thickness) and packed in composite polyethylene terephthalate (PET)/low density polyethylene (LDPE) film (50µ thickness) pouches and placed in PET box.

For selecting the type of jaggery as sugar replacement, three types of jaggery were used viz. Sugarcane jaggery, Palm jaggery and Coconut jaggery. Preliminary trials were taken to select the level of sugar replacement. Three batches of burfi were prepared viz. J1 (50% replacement with sugarcane jaggery), J2 (50% replacement with palm jaggery) and J3 (50% replacement with coconut jaggery). Control (C) was prepared using the same procedure without replacement of sugar.

Chemical analysis: The determine the moisture content of burfi, a gravimetric method based on the (FSSAI 01.039:2022). Fat extraction of burfi was determined by Rose-Gottlieb method described in Section (FSSAI 01.073:2022). Protein content in burfi was estimated by Kjeldahl method (FSSAI 01.062:2022). Total carbohydrate was derived by difference. Ash content in burfi was determined as per the method described by (FSSAI 01.077:2022). The free fatty acid (FFA) content of burfi was determined using the method described by Deeth *et al.* (1975) [1].

Colour value analysis: The colour value of pumpkin seed incorporated burfi was measured by chroma meter (Konica Minolta Chroma Meter CR-400, Japan).

Texture profile analysis: Burfi were subjected to uniaxial compression to 80% of the initial sample height, using a Food Texture Analyzer of Lloyd Instruments LRX Plus material testing machine, England; fitted with 0-500 kg load cell. The force-distance curve was obtained for a two-bite deformation cycle employing a Cross Head speed of 50 mm/min, Trigger 10 gf and 80% Compression of the samples to determine various textural attributes of burfi held for 1 h at 20±1 °C and 55% RH.

Sensory evaluation: For the sensory evaluation of burfi, a panel of 10 judges familiar with the typical characteristics of dairy-based sweets were selected. Panelists were chosen based on their regular consumption of such products and consistent sensory perception across evaluation sessions. The evaluation was carried out using a 9-point hedonic scale scorecard as recommended by Stone and Sidel (2004) [15].

Statistical analysis: Data obtained was statistically analysed using completely randomized design. Statistical analysis was carried out using one-way ANOVA through MS-Excel.

Results and discussion

Effect of partial replacement of sugar with different types of jaggery on sensory score of pumpkin seeds incorporated burfi

To select the most suitable form of jaggery for partial replacement of sugar in burfi, experimental samples viz., J1, J2, and J3 along with the control (C) were subjected to sensory evaluation.

As presented in Table 1, flavour scores ranged from 8.24 ± 0.12 (C) to 6.59 ± 0.15 (J1). The preference order was: $C > J2 > J3 > J1$. Statistical analysis showed a significant ($P < 0.05$) difference in flavour among the samples. The control (C) had the highest score, significantly ($P < 0.05$) better than all jaggery-incorporated samples. On the other hand, several researchers have reported an increase in flavour scores when jaggery was used as an alternative sweetener compared to sugar (Kumar *et al.*, 2024) [8]. Among the jaggery types, palm jaggery (J2) showed a significantly better flavour than sugarcane (J1) and coconut jaggery (J3). This suggests palm jaggery may be a better flavouring alternative in burfi.

Body and texture scores (Table 1) ranged from 7.31 ± 0.10 (C) to 7.52 ± 0.11 (J2). Differences were statistically non-significant ($P > 0.05$). J2 recorded the highest score (7.52 ± 0.11), followed by J3 (7.49 ± 0.13), J1 (7.33 ± 0.17), and the control (7.31 ± 0.10). These findings suggest that jaggery incorporation had no adverse effect on burfi's body and texture. Similar trends have been observed in other milk-based sweets when sugar cane jaggery was incorporated (Thakare, 2019) [16].

Scores for colour and appearance ranged from 8.51 ± 0.13 (C) to 6.64 ± 0.16 (J3). A significant ($P < 0.05$) difference was observed across samples. The control scored highest, followed by J2, while J3 scored lowest—likely due to the darker tone imparted by coconut jaggery. The colour variation may also be due to pigments from jaggery or pumpkin seeds. Similar trends have been observed in decrease in colour and appearance scores when jaggery was used as an alternative sweetener compared to sugar for burfi making (Kumar *et al.*, 2024) [8].

Overall acceptability ranged from 8.01 ± 0.15 (C) to 6.82 ± 0.12 (J1). Statistically significant differences ($P < 0.05$) were found. J2 had higher acceptability than J1 and J3, indicating palm jaggery as the most suitable among the alternatives in terms of flavour, colour, and overall liking.

Effect of partial replacement of sugar with different types of jaggery on chemical composition of pumpkin seeds incorporated burfi

The experimental samples J1, J2, and J3 along with the control (C) were analyzed for their moisture, free fatty acid (FFA), fat, protein, ash and carbohydrate contents and the results are presented in Table 2.

- **Moisture:** As shown in Table 2, moisture content ranged from $19.44 \pm 0.44\%$ (C) to $24.72 \pm 0.36\%$ (J3), increasing in the order: $C < J1 < J2 < J3$. The difference was significant ($P < 0.05$), with control having the lowest and J3 the highest moisture content. The rise in moisture with jaggery substitution is likely due to its hygroscopic nature. However, Kumar *et al.* (2024) [8] reported higher moisture in sugar-based burfi than in jaggery-based versions. Thakare (2019) [16] observed a non-significant ($P > 0.05$) decrease in moisture with higher jaggery levels. Factors such as jaggery type, replacement rate, ingredients and processing methods influence final moisture levels. This could be one of the reasons why in the present study 50% sugar replaced

with jaggery burfi has increased moisture content compared to control burfi.

- **Free fatty acids:** FFA content ranged from $0.527 \pm 0.02\%$ (J3) to $0.578 \pm 0.01\%$ (C), with no significant ($P > 0.05$) difference across samples. While slight variations were noted, they were not statistically significant.
- **Fat:** Fat content varied from $21.83 \pm 0.33\%$ (J3) to $22.79 \pm 0.17\%$ (C). Differences among jaggery added samples were non-significant ($P > 0.05$). The slightly higher fat in control may be due to its lower moisture level. Jaggery-added samples showed marginally lower fat content.
- **Protein:** Protein content ranged from $15.03 \pm 0.26\%$ (J3) to $15.25 \pm 0.23\%$ (J1), with non-significant ($P > 0.05$) difference. J1 (Sugarcane jaggery) showed a slight increase. Thakare (2019) [1] also found non-significant ($P > 0.05$) protein increases with jaggery in brown peda.
- **Ash:** Ash content, indicating mineral presence, was significantly different ($P < 0.05$), ranging from $2.88 \pm 0.05\%$ (C) to $3.04 \pm 0.02\%$ (J2). All jaggery-treated samples had higher ash content due to the natural minerals in jaggery. Kumar *et al.* (2024) found that ash content was significant ($P < 0.05$) higher in jaggery burfi because it jaggery have more mineral content than sugar. Thakare (2019) [16] also observed that addition of jaggery in milk for making brown Peda significantly ($P < 0.05$) increased the ash content of experimental brown Peda.
- **Carbohydrate:** Carbohydrate content ranged from $39.75 \pm 0.43\%$ (C) to $35.40 \pm 0.29\%$ (J3), showing a significant ($P < 0.05$) decrease in jaggery-based samples. The reduction is attributed to higher moisture and ash content in jaggery compared to the higher purity of sucrose in refined sugar. Kumar *et al.* (2024) [8] found that carbohydrate was lower in jaggery added burfi than control burfi because addition of cane sugar that have more purity of sucrose than jaggery.

Effect of partial replacement of sugar with different types of jaggery on rheological property of pumpkin seeds incorporated burfi

- The influence of partial sugar replacement with various types of jaggery on the rheological properties of pumpkin seed incorporated burfi was investigated and the results are presented in Table 3.
- **Hardness:** Hardness was highest in the control (34.86 ± 1.22 N), followed by J3 (22.64 ± 0.50 N), J2 (19.31 ± 1.44 N), and lowest in J1 (15.08 ± 0.93 N), with all differences significant ($P < 0.05$). Jaggery substitution, particularly sugarcane jaggery (J1), led to a softer texture, likely due to increased moisture and different solid contents and moisture-holding capacities of jaggery compared to refined sugar. Kumar *et al.* (2024) [8] found that, when the rate of jaggery addition increased, it was discovered that the hardness of experimental jaggery burfi significantly increased in all samples. Thakare, (2019) [16] observed that addition of jaggery in milk for brown Peda preparation was found to significantly ($P < 0.05$) increase the hardness of experimental brown Peda. Since hardness depends on various factors like different moisture, sweeteners, type of jaggery, the rate of sugar replacement with jaggery,

ingredients, manufacturing methods, heating time, etc. in the present study the increase in moisture content of jaggery added burfi could have resulted in lower hardness compared to control burfi.

- **Cohesiveness:** Cohesiveness reflects the internal bonding of the product structure. The values ranged from 0.011 ± 0.003 (J1) to 0.020 ± 0.002 (C and J2). J1 exhibited a significantly ($P < 0.05$) lower cohesiveness than the control and J2 ($P < 0.05$), while J3 (0.017 ± 0.003) did not differ significantly ($P > 0.05$) from C and J2. This suggests that sugarcane jaggery may disrupt internal structural bonding more than palm or coconut jaggery.
- **Chewiness:** Chewiness was highest in the control (0.609 ± 0.02 N mm), significantly ($P < 0.05$) greater than in J3 (0.253 ± 0.01 N mm), J2 (0.275 ± 0.02 N mm) and J1 (0.094 ± 0.03 N mm). All differences were statistically significant ($P < 0.05$). These results indicate that jaggery incorporation reduced the energy required to chew the product, likely due to a softer matrix and less cohesive texture. These results are in corroboration with those obtained by Kumar *et al.* (2024) who reported that when the rate of jaggery was replaced with sugar, the chewiness of experimental jaggery burfi significantly increased in all samples.
- **Adhesiveness:** Adhesiveness was highest in J3 (10.418 ± 0.09 N·mm), followed by C (5.001 ± 2.52), J2 (4.629 ± 2.97), and J1 (1.965 ± 1.26), with all differences significant ($P < 0.05$). The high adhesiveness in J3 may be due to sticky components in coconut jaggery.
- **Gumminess:** Gumminess was highest in the control (0.691 ± 0.03 N) and significantly lower in all jaggery samples, especially J1 (0.168 ± 0.01 N). This decreases likely results from reduced hardness and cohesiveness, possibly influenced by jaggery.
- **Springiness:** Springiness was highest in the control (0.868 ± 0.02 mm), and significantly ($P < 0.05$) lower in J1 (0.542 ± 0.03 mm), with intermediate values for J2 and J3. The decline suggests reduced elastic recovery, potentially due to jaggery's hygroscopic nature affecting the matrix structure.

Effect of partial replacement of sugar with different types of jaggery on colour of pumpkin seeds incorporated burfi

Colour of burfi samples was measured using a chroma meter and expressed in terms of L^* , a^* and b^* values are presented in Table 4.

- **L^* value:** The L^* value of burfi was significantly ($P < 0.05$) affected by partial replacement of sugar with different types of jaggery. The control (C) exhibited the highest L^* value (69.31 ± 0.12), indicating the lightest appearance, while J1 had the lowest (53.51 ± 0.15), suggesting a darker product. J2 (57.58 ± 0.10) and J3 (62.80 ± 0.16) showed intermediate values, following the trend: $C > J3 > J2 > J1$. This indicates that jaggery, especially sugarcane jaggery, darkens the burfi. Similar trends have been observed by Tripathi *et al.* (2022) that jaggery enriched yoghurt has significantly ($P < 0.05$) lower lightness (L^*) compared to control yoghurt.
- **a^* value:** The a^* value also differed significantly ($P < 0.05$). J1 showed the highest redness (6.00 ± 0.01), followed by J2 (4.36 ± 0.02), J3 (2.12 ± 0.01), and the control (-4.23 ± 0.16), which showed a greenish hue.

The trend: $J1 > J2 > J3 > C$. Jaggery addition increased the red hue, with sugarcane jaggery contributing the most. Similar trends have been observed by Tripathi *et al.* (2022) that jaggery enriched yoghurt has significantly ($P < 0.05$) higher redness (a^*) compared to control yoghurt.

- **b^* value:** Significant ($P < 0.05$) differences were also observed in the b^* value. J3 had the highest yellowness (21.72 ± 0.12), followed by J1 (18.54 ± 0.09), J2 (18.09 ± 0.17), and control (16.29 ± 0.13), showing the trend: $J3 > J1 > J2 > C$. All samples were on the yellow spectrum, with jaggery contributing to enhanced yellowness. Similar trends have been observed by Tripathi *et al.* (2022) that jaggery enriched yoghurt has significantly ($P < 0.05$) higher yellowness (b^*) compared to control yoghurt.

Conclusion

Among the three types of jaggery evaluated, palm jaggery consistently outperformed sugarcane and coconut jaggery across multiple parameters. It offered superior flavour and overall acceptability, enhanced the nutritional profile by increasing ash content (indicative of mineral enrichment) and maintained favourable textural integrity. In terms of colour, palm jaggery provided a moderate and visually appealing shift without excessive darkening. These findings support the selection of palm jaggery as a suitable sweetener for developing nutritionally enhanced and sensorially acceptable functional burfi.



Fig 1: C (upper left side), J1 (upper right side), J2 (lower left side) and J4 (lower right side)

Table 1: Effect of partial replacement of sugar with different types of jaggery on sensory score of pumpkin seeds incorporated burfi

Burfi samples	Sensory score (9-point hedonic scale)			
	Flavour	Body and texture	Color and appearance	Overall acceptability
C	$8.24^a \pm 0.12$	7.31 ± 0.10	$8.51^a \pm 0.13$	$8.01^a \pm 0.15$
J1	$6.59^d \pm 0.15$	7.33 ± 0.17	$6.94^b \pm 0.14$	$6.82^d \pm 0.12$
J2	$7.18^b \pm 0.09$	7.52 ± 0.11	$7.05^b \pm 0.10$	$7.26^b \pm 0.09$
J3	$6.91^c \pm 0.10$	7.49 ± 0.13	$6.64^c \pm 0.16$	$7.04^c \pm 0.10$
SEm $\pm$	0.07	0.08	0.08	0.07
CD (0.05)	0.22	NS	0.25	0.22
CV%	1.62	1.76	1.84	1.61

Each observation is a mean $\pm$ SD of 3 replicate experiments ($n=3$); Different superscripts in same column indicate significant differences at ($P < 0.05$)

Table 2: Effect of partial replacement of sugar with different types of jaggery on chemical composition of pumpkin seeds incorporated burfi

Burfi samples	Constituents (%)					
	Moisture	FFA	Fat	Protein	Ash	Carbohydrate
C	19.44 ^c ±0.44	0.578±0.01	22.79 ^a ±0.17	15.14±0.12	2.88 ^b ±0.05	39.75 ^a ±0.43
J1	22.83 ^b ±0.57	0.546±0.02	22.58 ^{ab} ±0.38	15.25±0.23	3.01 ^a ±0.03	36.33 ^b ±0.37
J2	23.88 ^a ±0.53	0.539±0.03	22.06 ^b ±0.25	15.12±0.18	3.04 ^a ±0.02	35.90 ^{bc} ±0.55
J3	24.72 ^a ±0.36	0.527±0.02	21.83 ^b ±0.33	15.03±0.26	3.02 ^a ±0.03	35.40 ^c ±0.29
Sem±	0.28	0.02	0.17	0.12	0.02	0.24
CD (0.05)	0.91	NS	0.55	NS	0.06	0.79
CV%	2.12	3.87	1.32	1.35	1.15	1.14

Each observation is a mean± SD of 3 replicate experiments (n=3);
Different superscripts in same column indicate significant differences at (*P*<0.05)

Table 3: Effect of partial replacement of sugar with different types of jaggery on rheological property of pumpkin seeds incorporated burfi

Burfi samples	Hardness (N)	Cohesiveness	Chewiness (N mm)	Adhesiveness (N mm)	Gumminess (N)	Springiness (mm)
C	34.86 ^a ±1.22	0.020 ^a ±0.002	0.609 ^a ±0.02	5.001 ^b ±2.52	0.691 ^a ±0.03	0.868 ^a ±0.02
J1	15.08 ^d ±0.93	0.01 ^c ±0.003	0.094 ^c ±0.03	1.965 ^d ±1.26	0.168 ^c ±0.01	0.542 ^c ±0.03
J2	19.31 ^c ±1.44	0.020 ^a ±0.002	0.275 ^d ±0.02	4.629 ^c ±2.97	0.383 ^b ±0.02	0.725 ^b ±0.04
J3	22.64 ^b ±0.50	0.017 ^b ±0.003	0.253 ^b ±0.01	10.418 ^a ±0.09	0.380 ^b ±0.02	0.679 ^b ±0.04
SEm±	0.62	0.00	0.01	0.08	0.01	0.02
CD (0.05)	2.03	0.01	0.03	0.27	0.04	0.06
CV%	4.70	16.38	5.14	2.59	5.23	4.77

Each observation is a mean± SD of 3 replicate experiments (n=3);
Different superscripts in same column indicate significant differences at (*P*<0.05)

Table 4: Effect of partial replacement of sugar with different types of jaggery on colour value of pumpkin seeds incorporated burfi

Burfi samples	L*	a*	b*
C	69.31 ^a ±0.12	-4.23 ^d ±0.16	16.29 ^d ±0.13
J1	53.51 ^d ±0.15	6.00 ^a ±0.01	18.54 ^b ±0.09
J2	57.58 ^c ±0.10	4.36 ^b ±0.02	18.09 ^c ±0.17
J3	62.80 ^b ±0.16	2.12 ^c ±0.01	21.72 ^a ±0.12
SEm±	0.08	0.01	0.08
CD (0.05)	0.25	0.05	0.24
CV%	0.22	1.24	0.70

Each observation is a mean± SD of 3 replicate experiments (n=3);
Different superscripts in same column indicate significant differences at (*P*<0.05)

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