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## Studies on chromatic properties and sensory evaluation of green chickpea (*Cicer Arietinum* L.) based value added burfi product

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#### ABSTRACT

Colour is one of the most important quality attributes influencing consumer acceptance of food products, as it is closely associated with freshness, appearance and overall quality. The present study aimed to develop a value-added burfi by incorporating fresh green chickpea paste and finger millet (ragi) flour and to evaluate its chromatic properties. Burfi products were prepared by blending 50 % khoa and 30 % sugar with varying levels of fresh green chickpea paste (12–20 %) and roasted finger millet flour (0–8 %). The mixture was heated, stirred until the desired consistency was achieved. After that the mixture was spread into trays, cooled, cut and packaged. Chromatic properties ( $L^*$ ,  $a^*$ ,  $b^*$ , chroma,  $b^*/a^*$ , hue angle, yellowness index, whiteness index, and browning index) were evaluated using standard methods. The highest values of  $L^*$ ,  $a^*$ ,  $b^*$ , chroma,  $b^*/a^*$ , hue angle, yellowness index, whiteness index, and browning index were recorded as 42.61 ( $T_1$ ), 0.59 ( $T_9$ ), 4.06 ( $T_9$ ), 4.10 ( $T_9$ ), 11.40 ( $T_6$ ), 84.86° ( $T_6$ ), 16.14 ( $T_9$ ), 31.52 ( $T_5$ ), and 12.92 ( $T_9$ ), respectively. And the sensory evaluation showed that the treatment  $T_9$  had the best overall acceptability, followed by  $T_1$  and  $T_2$ . The study concluded that burfi product was prepared by using 50 % khoa, 30 % sugar, 12 % finger millet flour, and 8 % fresh green chickpea paste produced a desirable colour and high consumer acceptability.

**Keywords:** Chromatic properties, Hunter colour values,  $L^*$   $a^*$   $b^*$  values, Sensory evaluation

#### Introduction

The demands for convenient and value-added foods have increased considerably in recent years due to growing consumer awareness regarding health, dietary quality and the functional properties of food ingredients. The focus of food product development is shifting to the incorporation of traditional foods with plant sources rich in nutrients and desirable sensory properties, resulting in better nutritional value and consumer acceptance (Singh *et al.*, 2020; Granato *et al.*, 2020; Kumar *et al.*, 2025) [1, 2]. Traditional Indian dairy products offer a great opportunity for such innovation as they are well accepted by consumers and can be enriched with functional ingredients such as cereals, pulses, fruits, vegetables etc. Burfi is one of the important khoa-based dairy sweets among the traditional dairy sweets, which is made by concentrating milk to khoa followed by adding sugar and other ingredients. The colour, flavour, body, texture and appearance are the characteristic features that are important to its overall acceptability (Deshmukh *et al.*, 2017; Viji *et al.*, 2023) [3, 4].

Fresh green chickpea has an interesting potential for product development as it is consumed at an immature stage with a characteristic green colour and good flavour and softness. The use of green chickpea paste in traditional foods could be another avenue for using the crop beyond the home use and create value added nutritious products. The green colour of the ingredient can also affect the visual properties of the final product, so that the chromatic properties are an important quality parameter. The processing conditions like heating, concentration and incorporation of ingredients can change the colour of food by degradation of pigment, enzymatic reactions, Maillard reactions and caramelization which may impact the consumer perception and acceptability of food (Pathare *et al.*, 2013; Martins *et al.*, 2000; Tamanna *et al.*, 2015) [6, 5, 7].

Finger millet (*Eleusine coracana* L.) or ragi is another cereal that is nutritionally important and is resilient to climate change. It is rich in carbohydrates, dietary fibre, protein, calcium, iron and is gaining more attention as a functional food ingredient (Devi *et al.*, 2014; Shobana *et al.*, 2013; Kalsi *et al.*, 2023) [8, 9, 10]. Finger millet is specially known for its nutritional and functional properties such as high calcium content, dietary fibre and polyphenolic compounds (Shobana *et al.*, 2013; Chethan *et al.*, 2007; Banusha *et al.*, 2017) [9, 12, 11]. Recent studies have shown its potential applications in value addition products like bakery products,

snacks, beverage and traditional foods (Sharma and Yamer, 2022 [13]; Kalsi *et al.*, 2023 [10]; Kaur *et al.*, 2024 [14]; Ravi and Rana, 2024 [15]; Tanwar *et al.*, 2025) [16].

The sensory characteristics and colour development in the final product are characteristic of the processing conditions (Aneja *et al.*, 2002; Deshmukh *et al.*, 2017) [17, 3]. The use of green chickpea paste and finger millet flour can, however, change the colour, appearance, taste, flavour and texture of burfi. Therefore, a systematic evaluation is needed to assess the level of incorporation that gives the desired product quality.

Colour is one of the initial quality attributes consumers perceive and is a major attribute that influences the visual appeal and perceived quality of foods. Instrumental colour measurement can give objective data that can reduce the subjectivity of visual assessment and can be used to determine the changes in chromatic properties. The CIE  $L^*$ ,  $a^*$ ,  $b^*$  system is a commonly used system for quantitative characterization of food colour, in which  $L^*$  stands for lightness,  $a^*$  for redness/greenness and  $b^*$  for yellowness/blueness (McGuire, 1992; Pathare *et al.*, 2013; León *et al.*, 2006) [19, 6, 18]. The changes in these parameters may give useful information regarding the effect of green chickpea, finger millet flour and heat processing on the colour of the developed burfi. The use of green chickpea may impart green colour and finger millet flour may impart reddish brown/dark colour, which may result in measurable variations in  $L^*$ ,  $a^*$  and  $b^*$  values.

Instrumental colour analysis provides an objective method for evaluating the appearance characteristics of food products. The Hunter colour system ( $L^*$ ,  $a^*$ ,  $b^*$ ) and CIE Lab colour scale are widely used in the food industry for measuring chromatic properties. The  $L^*$  value represents lightness or brightness, where lower values indicate darker colour and higher values indicate brighter colour. The  $a^*$  value indicates redness ( $+a^*$ ) and greenness ( $-a^*$ ), whereas the  $b^*$  value represents yellowness ( $+b^*$ ) and blueness ( $-b^*$ ) of the product (Pathare *et al.*, 2013; Keskin *et al.*, 2019) [6, 20]. also described that  $L^*$ ,  $a^*$ , and  $b^*$  values obtained through a colorimeter provide valuable information regarding changes in brightness, redness, and yellowness of processed food products. (Singh *et al.* 2020).

The color of foods is one of the most important quality factors for vegetables and plays a considerable role in the overall acceptability of foods. Color is a component of total appearance and incorporates visual recognition and assessment of the surface and subsurface properties (Ahmed *et al.*, 2002) [21]. Instrumental color measurement provides an indication of quality and tristimulus colorimetry is well established as a rapid and simple instrumental method to predict the visual perception of foods (Chua *et al.*, 2000) [22]. Color is most commonly represented in terms of  $L^*$ ,  $a^*$  and  $b^*$  values (brightness, green to red, blue to yellow, respectively) or a combination of these three parameters depending upon the nature of the pigment in the food material (Ahmed *et al.*, 2002; Chua *et al.*, 2000; Gong *et al.*, 2015; Etzbach *et al.*, 2019; Singh *et al.*, 2020) [21, 22, 23, 24] and optical properties.

Although several studies have been conducted on colour characteristics of processed fruits, vegetables, and dried food products, limited information is available regarding the effect of fresh green chickpea paste and finger millet flour incorporation on the chromatic properties of traditional dairy-based products such as burfi. Therefore, the present study was undertaken to evaluate the chromatic properties and sensory evaluation of fresh green chickpea and finger millet-based value-added burfi products. The study focused on determining the effect of different formulation ratios on chromatic values ( $L^*$ ,  $a^*$ ,  $b^*$ ), chroma, hue angle, yellowness index, whiteness index, browning index, and their relationship with sensory acceptability. The development of such a functional dairy product may provide enhanced nutritional quality along with desirable colour characteristics and consumer acceptance.

## 2. Materials and Methods

### 2.1 Selection of raw material

Amul Gold milk containing 6% fat and 9% SNF was procured from the local market of Dediapada, Gujarat and used for khoa preparation. The milk was heated at  $80 \pm 5$  °C with continuous stirring at 25–30 rpm until khoa reached the dough stage with about 31% moisture. Sugar was purchased locally and powdered using a mixer grinder. Finger millet flour was obtained from Krish Vigyan Kendra Dediapada, while fresh green chickpea was collected from the experimental field of College of Agricultural Engineering & Technology, Dediapada.

A 31 cm diameter  $\times$  8.5 cm depth stainless-steel deep metal pot, flat blade and induction stove were used for khoa preparation. Stainless-steel trays (45 cm  $\times$  25 cm  $\times$  2 cm) were used for setting the burfi and a digital weighing balance was used for weighing ingredients and samples.

### 2.2 Treatment details

Experimental details or different treatments with blending in different proportion of green chickpea paste, ragi flour, khoa and sugar were presented in Table 1.

### 2.3 Experimental procedure

Fresh milk was received, preheated to 38–40 °C, and filtered to remove impurities. It was then transferred to an open pan and heated with continuous stirring and scraping until khoa of semi-solid consistency was obtained. The required quantities of green chickpea paste and roasted finger millet flour were incorporated according to the treatment combinations and cooked for 5–8 min with continuous mixing. Sugar was subsequently added and the mixture was further cooked for 2–3 min until a smooth and uniform mass was formed.

The hot burfi mixture was spread uniformly in a clean stainless-steel tray and allowed to set at room temperature for 10–12 h. After complete cooling and setting, the burfi was cut into uniform pieces and packed in transparent food-grade plastic containers to protect the samples from contamination. The prepared samples were stored under suitable conditions and evaluated for their chromatic properties.

### 2.4 Chromatic properties

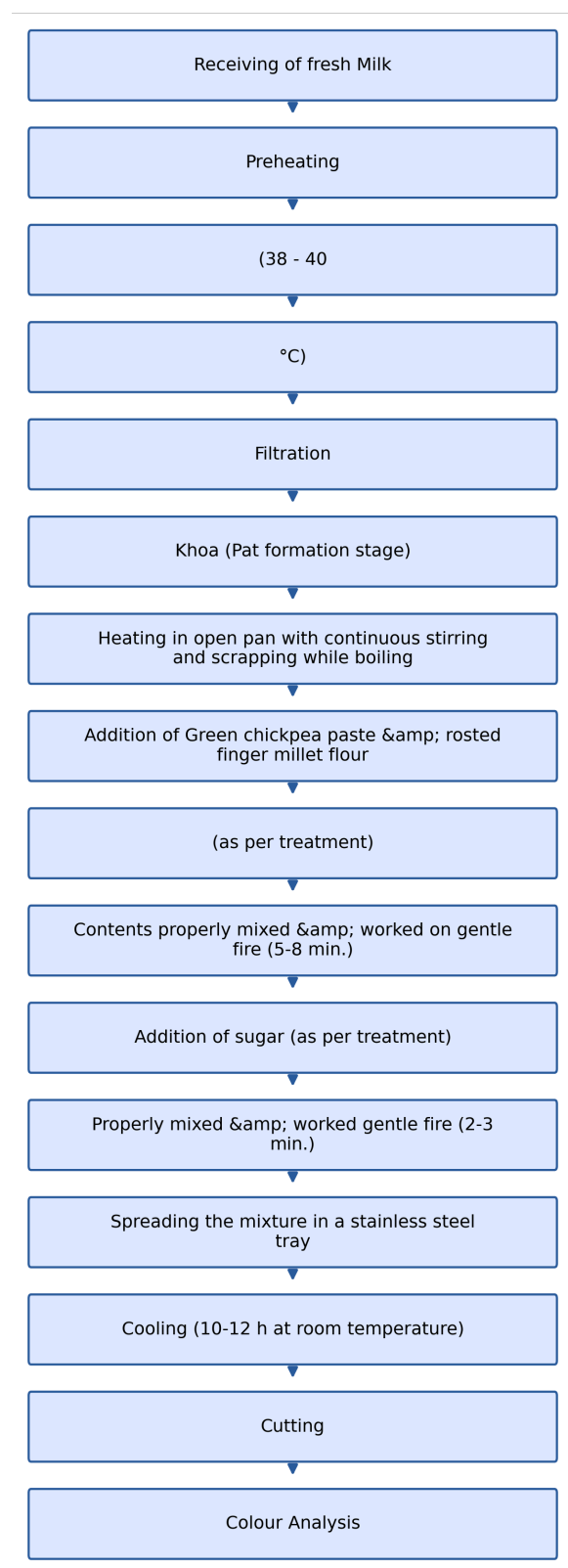
The hunter lab  $L^*$ ,  $a^*$ ,  $b^*$  and the modified CIE system called CIE LAB colour scale were opponents-type system commonly used in a food industry. The parameter  $a^*$  takes positive value for reddish colour and negative value for the greenish ones, whereas  $b^*$  takes positive value for yellowish colours and negative value for the bluish ones.  $L^*$  is an approximate measurement of luminosity, which is the property according to which each colour can be considered as equivalent to a number of the greyscale, between black white.

#### 2.4.1 $L^*$ value

Colour denotes the visual appearance of the product. The  $L^*$  value of dried carrots puree products represents the brightness of the colour.  $L = 0$ : indicate black colour and  $L = 100$ : indicate white colour. L scale: Light vs. dark where a low number (0-50) indicates dark and a high number (51-100) indicates bright (Keskin *et al.*, 2019; Singh *et al.*, 2022) [20]. The fresh burfi sample was kept on sample cylinder and the  $L^*$  value was observed). Repeat the experiment triplicate and calculate average value.

#### 2.4.2 $a^*$ value

The scale of  $a^*$  value: red vs. green, where  $(+a)$  positive number indicates red and  $(-a)$  negative number indicates green. The values of redness and greenness lies between +60 to -60 (Keskin *et al.*, 2019; Singh *et al.*, 2022) [20]. The Colorimeter was used for the experiment for colour measurement. The fresh burfi sample was kept on sample cylinder and the value  $a^*$  was observed. Repeat the experiment triplicate and calculate average value.



**Figure 1.** Flow chart for preparation of burfi products

#### 2.4.3 $b^*$ value

The  $b^*$  scale: yellow vs. blue, where (+b) positive number indicates yellow and (-b) negative number indicates blue. The values of yellowness and blueness lies between +60 to -60 (Keskin *et al.*, 2019; Singh *et al.*, 2022) [20]. The Colorimeter was used for the experiment for colour measurement. The fresh burfi sample was kept on sample cylinder and the value  $b^*$  was observed. Repeat the experiment triplicate and calculate average value.

#### 2.4.4 Darkness factor ( $b/a$ )

A darkness factor  $b^*/a^*$  was also used to quantify possible discoloration as well as redness ( $a^*$ ) and blueness ( $b^*$ ) factors. The ratio of 'b' value of hunter colour to 'a' value of hunter colour is called darkness factor of the product. The darkness factor of carrot puree was expressed as under given equation 1.

$$\text{Darkness factor} = b^*/a^* \quad (1)$$

#### 2.4.5 Chroma

Chroma ( $C^*$ ), considered the equivalent attribute of colour fullness, is used to determine the degree of difference of a hue in comparison to a grey colour with the same lightness. The higher the chroma values, the higher in the colour intensity of samples perceived by humans.

$$C = \sqrt{a^{*2} + b^{*2}} \quad \text{change in chroma: } \Delta C = C_{\text{sample}} - C_{\text{standard}} \quad (2)$$

#### 2.4.6 Hue angle

Hue angle ( $H^*$ ), considered the equivalent attribute of colour, is the attribute according to which colours have been traditionally defined as reddish, greenish, *etc.*, and it is used to define the difference of a certain colour with reference to grey colour with the same lightness. A higher hue angle represents a lesser yellow character in the assays. An angle of  $0^\circ$  or  $360^\circ$  represents red hue, whilst angle of  $90^\circ$ ,  $180^\circ$ , and  $270^\circ$  represents yellow, green and blue hues, respectively. It has been extensively used in the evaluation of colour parameters in green vegetables, fruits, and meats.

$$\text{Hue angle} = \tan^{-1} \left( \frac{b^*}{a^*} \right) \quad (3)$$

#### 2.4.7 Yellowness index

Yellowness Index ( $Y_I$ ) is associated with scorching, soiling and general products degradation by light, chemical exposure and processing. Yellowness indices are used chiefly to qualify these types of degradation with a single value. They can be used when measuring clear, near – colourless liquids or solid in transmission and near white, opaque solid in reflectance. Yellowness index ( $Y_I$ ) indicates the degree of yellowness.

$$Y_I = \frac{142.86b^*}{L^*} \quad (4)$$

#### 2.4.8 Whiteness index

Whiteness index ( $W_I$ ) is widely measured to yield numbers correlating closely with consumer's preferences for white colour. It mathematically combines lightness and yellow-blue into a single term. The  $W_I$  represents the overall whiteness of food products that may include the extent of discoloration during the processing.

$$WI = L - 3b + 3a \quad (5)$$

#### 2.4.9 Browning index

Browning coloration is an important phenomenon in food handling and processing including baking, drying and frying because it affects appearance quality. Therefore, the measurement and qualification of browning in food is important and industrial practice during sorting and grading to meet market requirement. It results from both enzymatic and non-enzymatic oxidation of phenolic compounds. The browning index ( $B_I$ ) is used to characterize the overall changes in browning colour. It is defined as brown colour purity and is one of the most common indicators of browning in food products containing sugar.

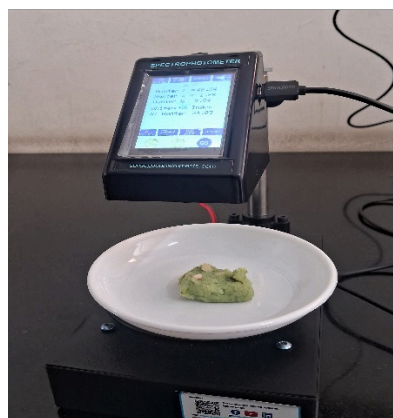
$$B_I = 100 \times \left( \frac{X - 0.31}{0.17} \right), \quad (6)$$

$$\text{where, } X = \frac{(a + 1.75L)}{(5.645L + a - 3.012b)}$$

#### 2.5. Sensory evaluation

Sensory analysis was performed at Department of Processing and Food Engineering, College of Agricultural Engineering & Technology (CAET), Dediapada. Different samples of burfi products were pre-

sented to panelists for sensory evaluation. Panelists were selected on the basis of their ability to discriminate and scale a broad range of different attributes. A panel of ten panelists were chosen to judge the quality the burfi (appearance, texture, colour, taste and overall acceptability using the scoring test of 1 to 9 points).



**Figure 2.** Chromatic analysis of fresh green chickpea-based burfi products by colorimeter

A semi-trained panel of 10 students and from faculty of the Agricultural Engineering and technology of CAET, Dediapada evaluated the burfi products for appearance, texture, colour, taste and overall acceptability on a 9-point hedonic scale. The panelists were naive to project objectives. Samples were coded using three-digit random numbers and served with the order of presentation counter-balanced. Panelists were provided with a glass of water, and were instructed to rinse and swallow water between samples. They were given written instructions and asked to evaluate the products for acceptability based on its appearance, texture, colour, taste and overall acceptability using nine-point hedonic scale.

### 3. Results and Discussions

The colour of the product is a very important quality parameter that plays a vital role in the acceptance and rejection of the product by the consumer. Colour characteristics were the most common parameter measured in food products as they are one of the first quality attributes that can be visualized by a consumer (Chua *et al.*, 2000; Singh *et al.*, 2022) [22]. Food colour is a major determinant of product quality and affects consumer preferences (Ahmed *et al.*, 2002; Samia, 2014) [21] and may be used as an indicator to predict the chemical and quality changes due to thermal processing. The evaluation of different chromatic properties viz.  $L^*$ ,  $a^*$ ,  $b^*$ , darkness factor ( $b/a$ ), Chroma ( $C^*$ ), Hue angle ( $H^\circ$ ), Yellowness Index ( $Y_I$ ), Whiteness index ( $W_I$ ) and Browning index ( $B_I$ ) of the burfi products were studied and illustrated in tabulated and graphically in subsequent headings.

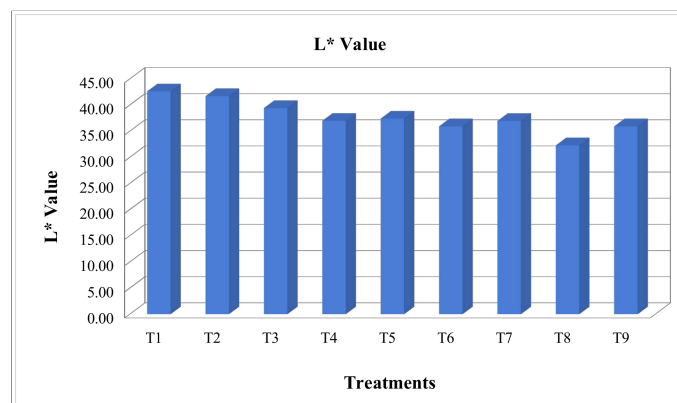
#### 3.1 Different chromatic properties of green chickpea-based value-added burfi product

The different chromatic values ( $L^*$ ,  $a^*$ ,  $b^*$ ,  $C$ ,  $b^*/a^*$ ,  $H^\circ$ ,  $W_I$ ,  $Y_I$ ,  $B_I$ ) of different burfi products were determined by colorimeter and their average were presented in Table 2 and 3 and presented in figure 3 to 11.

##### 3.1.1

##### $L^*$ Value

Colour is one of the significant quality parameters of food products and plays a significant role in consumer acceptability. The  $L^*$  value is a measure of lightness (0 – black, 100 – white), with higher  $L^*$  values reflecting a lighter or brighter product, and lower  $L^*$  values a darker product (McGuire, 1992; Pathare *et al.*, 2013; Singh *et al.*, 2022) [19, 6].



**Figure 3.** Effect of green chickpea, khoa and ragi flour on  $L^*$  value of green chickpea-based value-added burfi product

The green chickpea-based burfi products showed the  $L^*$  value ranging between 32.29 and 42.61 with the mean value of 37.69. The darkest colour was noted as the minimum  $L^*$  value 32.29 in T8.

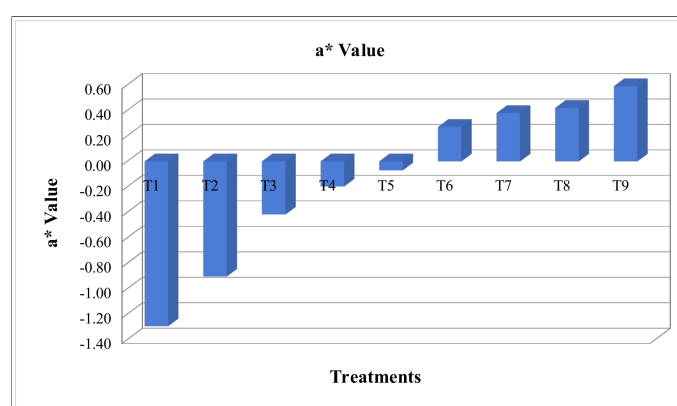
The difference in  $L^*$  values could be due to the different percentage of green chickpea paste and finger millet flour in the treatments. However, naturally finger millet is darker in colour because of the presence of its pigments and phenolic compounds that can reduce the lightness of food products if used at higher percentages (Sharma *et al.*, 2022) [13]. Likewise, the natural colour of chickpea is modified during processing as a result of thermal treatment (García-Parra *et al.*, 2016).

The lower  $L^*$  values could also be due to Maillard browning and caramelization during preparation of khoa and burfi. Heating accelerates the formation of brown pigments and therefore the final product is darker (Martins *et al.*, 2001). Therefore, T<sub>1</sub> gave the brightest burfi while T<sub>8</sub> gave the darkest burfi which showed that formulation and thermal processing played significant role in the lightness of the prepared green chickpea-based burfi.

##### 3.1.2

##### $a^*$ Value

The scale of  $a^*$  value: red vs. green, where (+ $a$ ) positive number indicates red and (− $a$ ) negative number indicates green. The values of redness and greenness lie between +60 to −60 (Keskin *et al.*, 2019; Singh *et al.*, 2022) [20]. The average  $a^*$  value of burfi product was obtainable in Table 2 and graphically represented in Figure 4.



**Figure 4.** Effect of green chickpea, khoa and ragi flour on  $a^*$  value of green chickpea-based value-added burfi product.

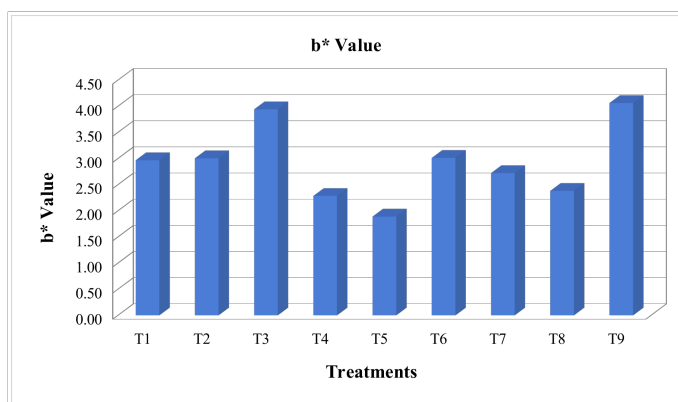
The  $a^*$  values of the treatments varied from −1.29 to 0.59, which means that the treatments had varying shades of green to red colour. T<sub>1</sub> had a significantly minimum  $a^*$  value of −1.29, which means that it was comparatively greener, while T<sub>9</sub> had a significantly maximum  $a^*$  value of 0.59, which means that it was comparatively more red. The  $a^*$  values showed a steady trend of increasing color from greenish to reddish as the treatment level went up from T<sub>1</sub> to T<sub>9</sub>.

Treatments T<sub>2</sub> (−0.90), T<sub>3</sub> (−0.42), T<sub>4</sub> (−0.20) and T<sub>5</sub> (−0.07) exhibited negative  $a^*$  values, indicating a slight green colour. In contrast, T<sub>6</sub> (0.27), T<sub>7</sub> (0.38), T<sub>8</sub> (0.42) and T<sub>9</sub> (0.59) showed positive  $a^*$  values, indicating a slight increase in redness. The variations in  $a^*$  values observed might be due to variations in the proportions of ingredients and their natural pigments in the various treatments. The shift of  $a^*$  from negative to positive values suggests a gradual shift in colour from greenish to reddish as the treatment levels increased.

The significant differences between the treatments (C.D. at 5% = 0.0659; S.E.m.± = 0.0222) showed that the product's redness – greenness was significantly affected by the treatment formulations. The experimental precision is relatively good with C.V. = 7.62%. The variation in  $a^*$  values may be attributed to differences in ingredient composition, pigment concentration and processing conditions. Abonyi *et al.* (2002) reported that lower  $a^*$  values indicate less intense red colour, whereas higher  $a^*$  values indicate greater redness. Changes in colour during processing may also occur due to moisture loss, structural changes and concentration of dry matter (Ibarz *et al.*, 1999). Similar effects of processing conditions on redness and greenness characteristics have been reported in processed food products (Keskin *et al.*, 2019) [20]. Therefore, the present findings indicate that the treatment formulation significantly influenced the redness–greenness characteristics of the developed products, with T<sub>1</sub> showing the highest greenness and T<sub>9</sub> showing the highest redness (Abonyi *et al.*, 2002; Ibarz *et al.*, 1999; Keskin *et al.*, 2019).

### 3.1.3 $b^*$ value

The colour axis from yellow to blue was represented by the  $b^*$  value, with a positive (+ $b^*$ ) value indicating yellowness and a negative (− $b^*$ ) value indicating blueness. The general range of  $b^*$  values for yellowness and blueness was taken as +60 to −60 (Keskin *et al.*, 2019) [20]. The average  $b^*$  values of the developed products were shown in Table 2 and graphically illustrated in Figure 5.



**Figure 5.** Effect of green chickpea, khoa and ragi flour on  $b^*$  value of green chickpea-based value-added burfi product.

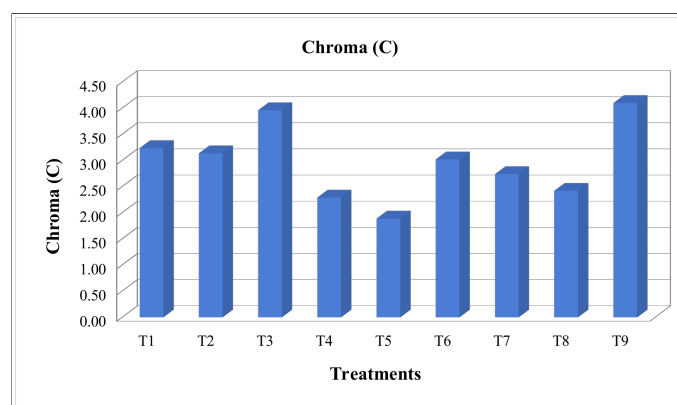
The  $b^*$  values of the developed products were positive and ranged from 1.89 to 4.06, which means all the treatments had a yellow colour. The significantly maximum  $b^*$  value of 4.06 was observed in T<sub>9</sub>, followed by 3.94 in T<sub>3</sub>, while the significantly minimum  $b^*$  value of 1.89 was recorded in T<sub>5</sub>.

The results showed that the highest intensity of yellowness was found in T<sub>9</sub> and the lowest intensity of yellowness was found in T<sub>5</sub>. The  $b^*$  values obtained under the different treatments had considerable variation, which may have been attributed to the differences in ingredients proportion and natural pigments and processing conditions. Yellowness of the products was reflected by the higher positive  $b^*$  values. Similar observations were reported by Abonyi *et al.* (2002), who stated that higher positive  $b^*$  values were associated with greater yellow colour intensity in processed food products. Changes in yellowness during processing might have resulted from moisture re-

moval, alteration of the internal structure, changes in surface characteristics and concentration of dry matter (Ibarz *et al.*, 1999). Processing conditions could also have influenced the colour characteristics through changes in natural pigments and heat-induced reactions (Keskin *et al.*, 2019) [20]. In the present study, the significant difference among treatments (C.D. at 5% = 0.1594) indicated that the treatment formulation had a significant effect on the  $b^*$  value. The S.E.m.± (0.0536) and C.V. (3.18%) indicated good experimental precision. Therefore, the highest yellowness was observed for T<sub>9</sub>, while the lowest yellowness was observed for T<sub>5</sub> among the developed products.

### 3.1.4 Chroma (C) value

The chroma (C) values of the developed green chickpea-based burfi products were presented in Table 2 and graphically represented in fig. 6. The chroma was the intensity or saturation of colour and was calculated based on the  $a^*$  and  $b^*$  values with the formula:  $C = \sqrt{a^{*2} + b^{*2}}$ .



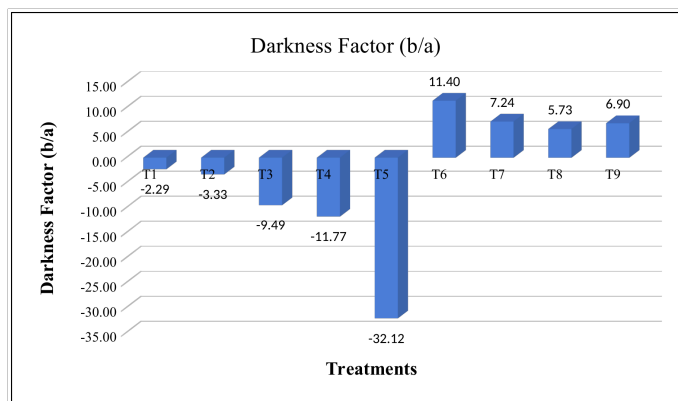
**Figure 6.** Effect of green chickpea, khoa and ragi flour on C value of green chickpea-based value-added burfi product.

The higher the C value, the more intense the colour, and the lower the C value, the less saturated the colour (CIE, 1976). The C values of the burfi samples ranged from 1.89 to 4.10, with an overall mean of 2.98. Among the treatments, T<sub>9</sub> recorded the highest C value (4.10), followed by T<sub>3</sub> (3.96), T<sub>1</sub> (3.24). T<sub>5</sub> (1.89) had the lowest C value. The chroma value of the T<sub>9</sub> was higher than the T<sub>5</sub>, signifying a more intense colour and more saturated than the T<sub>5</sub>.

The difference in the chroma values between the treatments was suggested to be due to the different amounts of green chickpea paste and finger millet flour used in the preparation of burfi. The heating and concentration steps used to make the burfi may have affected the colour intensity of the products developed using these ingredients, and the natural pigments that exist in these ingredients may have also contributed to the colour intensity of the products (Liu *et al.*, 2016). Instrumental colour measurements were extensively applied for the assessment of colour changes and quality properties of food products (CIE, 1976). The statistical analysis revealed a C.D. of 0.1544 at 5% on which the means of all the treatments differed significantly provided the difference was greater than C.D. There was good experimental precision, with a S.E.m.± of 0.0519, and a relatively low number of observations were varied, with a C.V. of 3.0206 %. The treatments had significant difference in chroma values and the colour intensity of the developed burfi product in treatment T<sub>9</sub> was the highest.

### 3.1.5 Darkness factor ( $b^*/a^*$ )

The relative colour characteristics of green chickpea-based value-added burfi products were described by the darkness factor ( $b^*/a^*$ ). The average darkness factor ( $b^*/a^*$ ) values of the different treatments were presented in Table 2 and graphically represented in Figure 7.



**Figure 7.** Effect of green chickpea, khoa and ragi flour on  $b^*/a^*$  value of green chickpea-based value-added burfi product

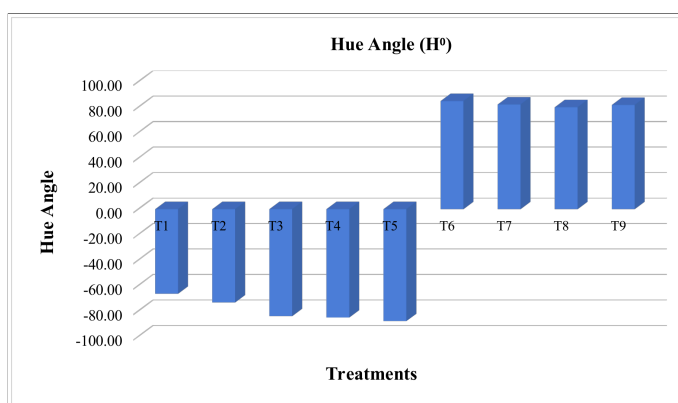
Darkness factor values ranged from  $-32.12$  to  $11.40$  across the treatments.  $T_5$  had the lowest value ( $-32.12$ ) and  $T_6$  had the highest value ( $11.40$ ). The values for the treatments  $T_7$ ,  $T_8$  and  $T_9$  were  $7.24$ ,  $5.73$  and  $6.90$ , respectively. The overall mean darkness factor was  $10.03$  with critical difference (C.D.) of  $8.9914$  at 5 per cent.

This difference in darkness factor between the green chickpea-based burfi treatments may have been due to the varying amount of green chickpea paste and finger millet flour added in the formulation of the burfi. Phenolic compounds and pigments naturally present in finger millet may be responsible for darker colour and greenish colour from green chickpea may be responsible for characteristic greenish colour of the product. The colour changes in the burfi could also have been caused by the heating and concentration of milk; chickpea paste and finger millet flour during the preparation of the burfi. (Sharma *et al.*, 2020; Singh *et al.*, 2020; Devi *et al.*, 2021).

For the  $b/a$ , highest value was observed for  $T_6$  and none of the treatments were at par with it. The results suggested that incorporation of green chickpea and finger millet at different levels affected the visual colour characteristics of the developed burfi. Such changes in colour parameters have been reported in value added food products with the use of cereal, millet and legume-based ingredients (Shobana *et al.*, 2013; Devi *et al.*, 2021; Singh *et al.*, 2020) [9]. In general, it was observed that darkness factor was significant for the formulation of the treatment and thermal processing to produce the final colour of green chickpea and finger millet value-added burfi.

### 3.1.6 Hue angle ( $H^\circ$ )

The hue angle ( $H^\circ$ ), which was derived from the Hunter colour coordinates, was used to represent the dominant colour shade of the value-added burfi produced using green chickpea. It showed the location of the product colour in the chromaticity plane, and the variation in the  $H^\circ$  value was due to the relative contribution of redness, yellowness, greenness and blueness. The  $H^\circ$  values of the developed burfi products are shown in Table 3 and graphically in Fig. 8.

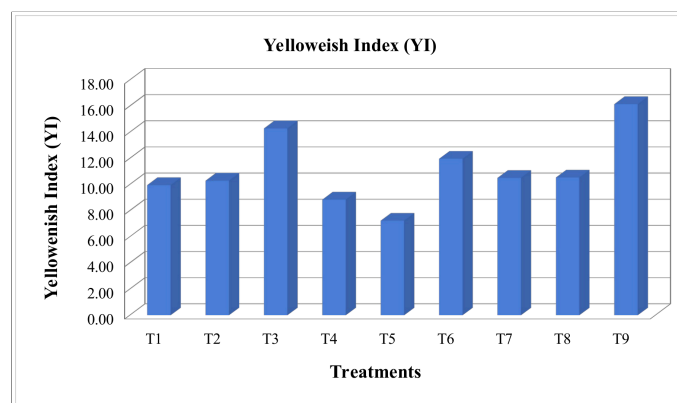


**Figure 8.** Effect of green chickpea, khoa and ragi flour on  $H^\circ$  value of green chickpea-based value-added burfi product.

The  $H^\circ$  values of the different treatments varied from  $-87.88^\circ$  to  $84.86^\circ$ . The maximum  $H^\circ$  value of  $84.86^\circ$  was recorded in  $T_6$ , whereas the minimum value of  $-87.88^\circ$  was observed in  $T_5$ . The  $H^\circ$  values of  $T_1$ ,  $T_2$ ,  $T_3$  and  $T_4$  were  $-66.41^\circ$ ,  $-73.24^\circ$ ,  $-83.96^\circ$  and  $-85.09^\circ$ , respectively. In comparison, treatments  $T_7$ ,  $T_8$  and  $T_9$  recorded  $H^\circ$  values of  $82.09^\circ$ ,  $80.00^\circ$  and  $81.74^\circ$ , respectively. The mean value was  $80.58^\circ$ , with a C.D. at 5% of  $1.5685$ , S.E.m.± of  $0.5279$  and C.V. of  $1.13\%$ . The significant differences among the treatments indicated that the proportions of green chickpea, khoa and finger millet flour had a significant influence on the hue characteristics of the developed burfi. The comparatively higher  $H^\circ$  value recorded for  $T_6$  ( $84.86^\circ$ ) suggested that the colour position was closer to the yellow side of the colour plane while a negative  $H^\circ$  value recorded for  $T_5$  ( $-87.88^\circ$ ) meant that the colour position was on the other side of the colour plane. The difference in the proportion of the green chickpea pastes and finger millet flour used in the preparation of the burfi might have been a reason for the large difference between the treatments. Green chickpea has natural pigments and phenolic compounds which are responsible for its green colour, whereas finger millet has phenolic compounds and other colour contributing components that can affect the end colour of processed food (Devi *et al.*, 2014; Xiang *et al.*, 2019) [8, 25]. Thus, the ratio of the ingredients may have changed, which might have influenced the proportion of the colour coordinates and hence the resulting hue angle. The relatively higher  $H^\circ$  values obtained for  $T_6$ ,  $T_7$ ,  $T_8$  and  $T_9$  formulations indicated that these formulations possessed more yellowish colour component. The interaction of the natural colour of green chickpea with the colour of finger millet and the milk solids during heating may have been responsible for this colour development. It is reported that finger millet contains phenolic acids, flavonoids and other phytochemicals which are responsible for its colour and functional properties (Xiang *et al.*, 2019) [25].

### 3.1.7 Yellowish index ( $Y_I$ )

The yellowish index ( $Y_I$ ) of the green chickpea-based value-added burfi was calculated from the Hunter colour parameters and results are shown in Table 3 and Fig. 9.



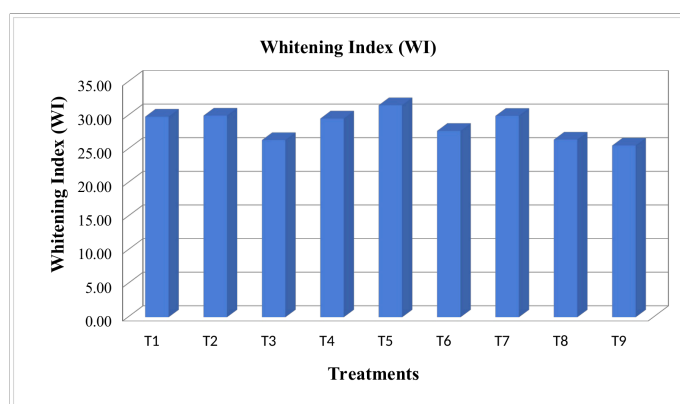
**Figure 9.** Effect of green chickpea, khoa and ragi flour on  $Y_I$  value of green chickpea-based value-added burfi product.

The  $Y_I$  values were varied from  $7.23$  to  $16.14$ . The highest  $Y_I$  value ( $16.14$ ) was observed in  $T_9$ , followed by  $T_3$  ( $14.29$ ) and  $T_6$  ( $11.97$ ), whereas the lowest value ( $7.23$ ) was recorded in  $T_5$ . The higher  $Y_I$  value of  $T_9$  showed comparatively more yellowish colour whereas the lower value of  $T_5$  showed comparatively less yellowness. Variations in the amount of green chickpea paste and finger millet flour used could have been responsible for the differences between the treatments, thereby affecting the overall colour composition of the burfi. The yellowish colour might also be due to the heat and concentration of milk and other ingredients that were used in making the burfi. The colored compounds and alteration in the appearance of dairy products may occur due to thermal processing leading to Maillard reactions and caramelization (Tamanna *et al.*, 2015) [7]. This relatively high  $Y_I$

obtained in T<sub>9</sub> may thus be a result of the mixing of the ingredients and their thermal treatment.

### 3.1.8 Whitening index ( $W_1$ )

The relative whiteness of the developed value-added burfi products based on green chickpea were indicated by whitening index ( $W_1$ ). The different treatments were presented in terms of their  $W_1$  values in Table 3 and graphically in Figure 10.



**Figure 10.** Effect of green chickpea, khoa and ragi flour on ( $W_1$ ) value of green chickpea-based value-added burfi product.

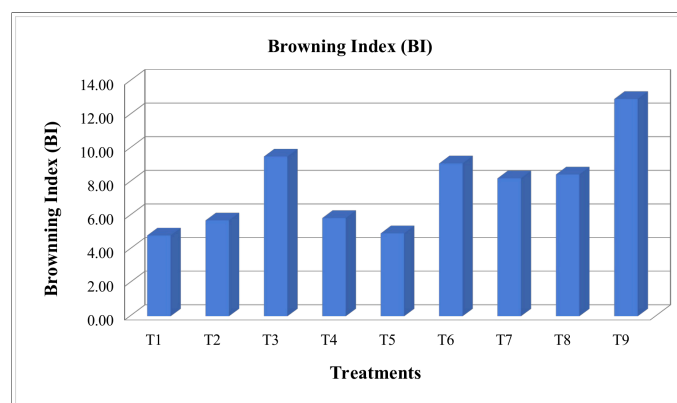
The results indicated that  $W_1$  for the different treatments ranged from 25.53 to 31.52. The maximum  $W_1$  value (31.52) was recorded for T<sub>5</sub>, followed by T<sub>2</sub> (29.98), whereas the minimum  $W_1$  value (25.53) was observed for T<sub>9</sub>. The higher  $W_1$  value of T<sub>5</sub> suggested a lighter and whiter colour appearance, while the lower  $W_1$  value of T<sub>9</sub> suggested a darker colour appearance. The differences in  $W_1$  may be due to different quantity of green chickpea paste and finger millet flour added to the burfi. The lightness and whiteness of food products may be decreased by the incorporation of finger millet at higher levels because it generally has darker colour and contains phenolic compounds (Devi *et al.*, 2014; Xiang *et al.*, 2019) [8, 25]. The relatively higher  $W_1$  of T<sub>5</sub> could be linked to the higher proportion of the khoa to the product colour, which leads to a lighter product. The lower  $W_1$  in T<sub>9</sub> on the other hand may have been due to the higher influence of finger millet and green chickpea components as well as the colour changes during heating. Thermal treatment of milk-based products may facilitate Maillard reactions and caramelization, resulting in the formation of colored compounds and thus decreasing the whiteness of the product (Tamanna *et al.*, 2015) [7]. The statistical results also showed that the  $W_1$  of T<sub>5</sub> was the highest whereas T<sub>9</sub> had the lowest  $W_1$ . Treatments T<sub>1</sub>, T<sub>2</sub> and T<sub>4</sub> were not significantly different from T<sub>5</sub>, which means that they whitened similarly. The low coefficient of variation (2.93%) indicated good precision of the experimental observations. The overall results indicated that the whitening index and visual appearance of the green chickpea value-added burfi were significantly affected by the ingredients and thermal processing.

### 3.1.9 Browning index ( $B_1$ )

The browning index ( $B_1$ ) was calculated to find the extent of brown colour development in value added burfi products of green chickpea. The  $B_1$  values of various treatments were shown in table 3 and graphically represented in fig. 11.

Significant variation was observed among the treatments, with  $B_1$  values ranging from 4.80 to 12.92. The lowest  $B_1$  value (4.80) was found in T<sub>1</sub> while the highest value (12.92) was found in T<sub>9</sub>. T<sub>9</sub> had the highest  $B_1$  which showed more development of brown colour than the other treatments. The difference in the  $B_1$  among the treatments might be due to the amount of green chickpea paste and finger millet (*ragi*) flour added to the burfi. Finger millet has a phenolics content and other phytochemicals which can be responsible for darkening of the food products during processing (Devi *et al.*, 2014; Xiang *et al.*, 2019) [8, 25]. Thus, the relative browning could have been higher in treatments which had a higher proportion of finger millet. The in-

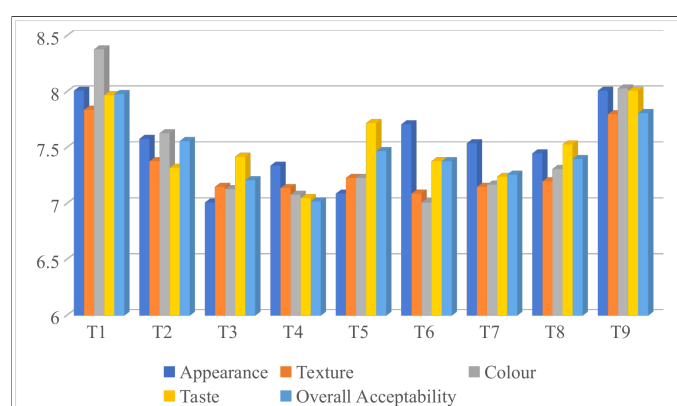
creased  $B_1$  of T<sub>9</sub> (12.92) may also be due to the heating and concentration method adopted in the preparation of burfi. The heating of milk, sugar and cereal/legume ingredients encourages Maillard reactions and caramelization, which results in the formation of brown compounds and therefore increases the browning index (Tamanna *et al.*, 2015) [7]. The lower  $B_1$  value of T<sub>1</sub> (4.80) indicated comparatively less browning and lighter colour. Thus, the results showed that T<sub>9</sub> had the highest browning degree, and T<sub>1</sub> had the lowest browning degree. The large differences between the treatments indicated that the formulation and thermal processing had an impact on the browning properties of the resulting burfi. The relatively low C.V. (4.02%) also suggested good consistency of the experimental measurements.



**Figure 11.** Effect of green chickpea, khoa and ragi flour on browning index (BI) value of green chickpea-based value-added burfi product.

### 3.2 Sensory evaluation

The sensory evaluation of the value-added burfi made of green chickpea was performed on the basis of appearance, texture, colour, taste and overall acceptability. The results were presented in Table 4 and graphically represented in Fig 12.



**Figure 4.12.** Effect of green chickpea, khoa and ragi flour on appearance, texture, colour, taste and overall acceptability of green chickpea-based value-added burfi product.

Significant differences were observed among the treatments for all the sensory attributes. For appearance, the highest value (8.01) was recorded for T<sub>1</sub> and T<sub>9</sub>, while the lowest score (7.01) was observed for T<sub>3</sub>. The texture score was highest in T<sub>1</sub> (7.84) and lowest in T<sub>6</sub> (7.09). For colour, T<sub>1</sub> obtained the highest score of 8.38, whereas T<sub>6</sub> recorded the lowest score of 7.01. In terms of taste, the highest score (8.01) was observed in T<sub>9</sub>, while the lowest score (7.05) was recorded in T<sub>4</sub>. T<sub>1</sub> achieved the highest overall acceptability score (7.98) while T<sub>4</sub> had the lowest score (7.02). The variations of sensory scores could be attributed to the different proportions of green chickpea paste and finger millet flour used which influenced the appearance, colour, texture and taste of the burfi. The sensory and textural characteristics of food products may be affected by the incorporation of finger millet due to its fibre and phenolic content (Devi *et al.*, 2014; Shobana *et al.*,

2013) [8, 9]. The results showed that the overall best treatment was T<sub>1</sub> and the best appearance and taste was obtained with T<sub>9</sub>. These are similar results that have been observed with millet value-added prod-

ucts with optimum levels of the ingredients enhancing the nutritional value and retaining good sensory properties (Shobana *et al.*, 2013; Xiang *et al.*, 2019) [9, 25].

**Table 1.** Different blending proportion of ingredients for burfi product

| Sr. No. | Sample code    | Blending Proportion of different cereals                                     |
|---------|----------------|------------------------------------------------------------------------------|
| 1.      | T <sub>1</sub> | 50 % Khoa + 30 % Sugar + 20 % Green Chickpea paste + 0 % Finger millet flour |
| 2.      | T <sub>2</sub> | 50 % Khoa + 30 % Sugar + 19 % Green Chickpea paste + 1 % Finger millet flour |
| 3.      | T <sub>3</sub> | 50 % Khoa + 30 % Sugar + 18 % Green Chickpea paste + 2 % Finger millet flour |
| 4.      | T <sub>4</sub> | 50 % Khoa + 30 % Sugar + 17 % Green Chickpea paste + 3 % Finger millet flour |
| 5.      | T <sub>5</sub> | 50 % Khoa + 30 % Sugar + 16 % Green Chickpea paste + 4 % Finger millet flour |
| 6.      | T <sub>6</sub> | 50 % Khoa + 30 % Sugar + 15 % Green Chickpea paste + 5 % Finger millet flour |
| 7.      | T <sub>7</sub> | 50 % Khoa + 30 % Sugar + 14 % Green Chickpea paste + 6 % Finger millet flour |
| 8.      | T <sub>8</sub> | 50 % Khoa + 30 % Sugar + 13 % Green Chickpea paste + 7 % Finger millet flour |
| 9.      | T <sub>9</sub> | 50 % Khoa + 30 % Sugar + 12 % Green Chickpea paste + 8 % Finger millet flour |

**Table 2.** Variation in L\*, a\*, b\*, C and b\*/a\* value of different products for burfi

| Sr. No. | Treatments     | L*     | a*     | b*     | C      | b*/a*   |
|---------|----------------|--------|--------|--------|--------|---------|
| 1       | T <sub>1</sub> | 42.61  | -1.29  | 2.97   | 3.24   | -2.29   |
| 2       | T <sub>2</sub> | 41.70  | -0.90  | 3.00   | 3.14   | -3.33   |
| 3       | T <sub>3</sub> | 39.41  | -0.42  | 3.94   | 3.96   | -9.49   |
| 4       | T <sub>4</sub> | 36.98  | -0.20  | 2.28   | 2.29   | -11.77  |
| 5       | T <sub>5</sub> | 37.41  | -0.07  | 1.89   | 1.89   | -32.12  |
| 6       | T <sub>6</sub> | 35.93  | 0.27   | 3.01   | 3.02   | 11.40   |
| 7       | T <sub>7</sub> | 36.96  | 0.38   | 2.72   | 2.74   | 7.24    |
| 8       | T <sub>8</sub> | 32.29  | 0.42   | 2.38   | 2.42   | 5.73    |
| 9       | T <sub>9</sub> | 35.94  | 0.59   | 4.06   | 4.10   | 6.90    |
|         | Mean           | 37.69  | 0.50   | 2.92   | 2.98   | 10.03   |
|         | C.D. at 5 %    | 1.3345 | 0.0659 | 0.1594 | 0.1544 | 8.9914  |
|         | S. Em.         | 0.4492 | 0.0222 | 0.0536 | 0.0519 | 3.0262  |
|         | C.V. (%)       | 2.064  | 7.6167 | 3.1846 | 3.0206 | 52.2594 |

**Table 3.** Variation in H<sup>0</sup>, YI, WI and BI value of different products for burfi

| Sr. No. | Treatments     | H <sup>0</sup> | YI    | WI    | BI   |
|---------|----------------|----------------|-------|-------|------|
| 1       | T <sub>1</sub> | -66.41         | 9.95  | 29.82 | 4.80 |
| 2       | T <sub>2</sub> | -73.24         | 10.29 | 29.98 | 5.70 |
| 3       | T <sub>3</sub> | -83.96         | 14.29 | 26.34 | 9.50 |

(continued on next page)

| Sr. No. | Treatments     | H <sup>0</sup> | YI     | WI     | BI     |
|---------|----------------|----------------|--------|--------|--------|
| 4       | T <sub>4</sub> | -85.09         | 8.84   | 29.54  | 5.84   |
| 5       | T <sub>5</sub> | -87.88         | 7.23   | 31.52  | 4.93   |
| 6       | T <sub>6</sub> | 84.86          | 11.97  | 27.71  | 9.09   |
| 7       | T <sub>7</sub> | 82.09          | 10.50  | 29.94  | 8.20   |
| 8       | T <sub>8</sub> | 80.00          | 10.53  | 26.41  | 8.43   |
| 9       | T <sub>9</sub> | 81.74          | 16.14  | 25.53  | 12.92  |
|         | Mean           | 80.58          | 11.08  | 28.53  | 7.71   |
|         | C.D. at 5 %    | 1.5685         | 0.6954 | 1.4355 | 0.5321 |
|         | S. Em. ±       | 0.5279         | 0.2341 | 0.4831 | 0.1791 |
|         | C.V. (%)       | 1.1346         | 3.6579 | 2.9328 | 4.0225 |

**Table 4.** Variation in appearance, texture, colour, taste and overall acceptability of different burfi products

| Sr. No. | Treatments     | Appearance | Texture | Colour | Taste  | Overall Acceptability |
|---------|----------------|------------|---------|--------|--------|-----------------------|
| 1       | T <sub>1</sub> | 8.01       | 7.84    | 8.38   | 7.97   | 7.98                  |
| 2       | T <sub>2</sub> | 7.58       | 7.38    | 7.63   | 7.32   | 7.56                  |
| 3       | T <sub>3</sub> | 7.01       | 7.15    | 7.13   | 7.42   | 7.21                  |
| 4       | T <sub>4</sub> | 7.34       | 7.14    | 7.08   | 7.05   | 7.02                  |
| 5       | T <sub>5</sub> | 7.09       | 7.23    | 7.23   | 7.72   | 7.47                  |
| 6       | T <sub>6</sub> | 7.71       | 7.09    | 7.01   | 7.38   | 7.38                  |
| 7       | T <sub>7</sub> | 7.54       | 7.15    | 7.17   | 7.24   | 7.26                  |
| 8       | T <sub>8</sub> | 7.45       | 7.20    | 7.31   | 7.53   | 7.40                  |
| 9       | T <sub>9</sub> | 8.01       | 7.80    | 8.03   | 8.01   | 7.81                  |
|         | Mean           | 7.53       | 7.33    | 7.44   | 7.52   | 7.45                  |
|         | C.D. at 5 %    | 0.6564     | 0.3118  | 0.3559 | 0.3676 | 0.2974                |
|         | S. Em.         | 0.2209     | 0.105   | 0.1198 | 0.1237 | 0.1001                |
|         | C.V. (%)       | 5.0846     | 2.48    | 2.7881 | 2.851  | 2.3248                |

## Conclusion

The maximum value of different chromatic value *i.e.*  $L^*$ ,  $a^*$ ,  $b^*$ ,  $c^*$ , ( $b^*/a^*$ ),  $H^0$ ,  $Y_I$ ,  $W_I$ , and  $B_I$  of burfi products were observed 42.61 (T<sub>1</sub>), 0.59 (T<sub>9</sub>), 4.06 (T<sub>9</sub>), 4.10 (T<sub>9</sub>), 11.40 (T<sub>6</sub>), 84.86<sup>0</sup> (T<sub>6</sub>), 16.14 (T<sub>9</sub>), 31.52 (T<sub>5</sub>), and 12.92 (T<sub>9</sub>) respectively and minimum value were observed 32.29 (T<sub>8</sub>), -1.29 (T<sub>1</sub>), 1.89 (T<sub>5</sub>), 1.89 (T<sub>5</sub>), -32.12 (T<sub>7</sub>), -88.88<sup>0</sup> (T<sub>5</sub>), 7.23 (T<sub>5</sub>), 25.53 (T<sub>9</sub>) and 4.80 (T<sub>1</sub>) respectively.

Sensory evaluation using a 9-point hedonic scale by a panel of 10 semi-trained panelists further confirmed that all treatments were generally acceptable. T<sub>1</sub> obtained the highest colour score (8.38) and texture score (7.84), while both T<sub>1</sub> and T<sub>9</sub> recorded the highest appearance score (8.01). T<sub>9</sub> obtained the highest taste score (8.01). For overall acceptability, T<sub>1</sub> recorded the highest score of 7.98, followed by T<sub>9</sub> (7.81) and T<sub>2</sub> (7.56).

On the basis of overall studied properties, we observed that the treatment T<sub>9</sub> was found best among all the treatments followed by T<sub>1</sub> and T<sub>2</sub>. Therefore, we can recommend that the fresh green chickpea and finger millet-based value-added burfi products prepared using 50 % khoa + 30 % sugar + 12 % ragi + 8 % fresh green chickpea paste by blending and stirring process.

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