ORIGINAL ARTICLE

Evaluation of Physical Properties and Color characteristics of Millets based Cookies blended with Carrot-powder

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Abstract

Aim: The study focused on determining changes in diameter, thickness, weight, spread ratio, and color parameters (L*, a*, b*) using standard analytical methods. The experiment also aimed to assess the sensory quality of cookies formulated with varying levels of carrot powder to identify the most acceptable blend. **Material and Methods:** Millet-based cookies were prepared by incorporating different levels of carrot powder (T_0–T_4 treatments). The dough was mixed, shaped, and baked under standard conditions. Physical properties such as diameter, thickness, weight, and spread ratio were determined using standard methods. Color values (L*, a*, b*) were measured with a colorimeter. Sensory evaluation was conducted by a semi-trained panel using a 9-point hedonic scale to assess overall acceptability. **Result and Discussion:** Incorporation of carrot powder into millet-based cookies significantly influenced their physical and color characteristics. The diameter decreased slightly from 5.73 cm (T_0) to 5.60 cm (T_4), while thickness and weight increased from 0.92 cm to 1.14 cm and 13.91 g to 17.71 g, respectively. The spread ratio showed a declining trend from 6.22 (T_0) to 4.91 (T_4). Color values indicated reduced lightness (L*) and variable redness (a*) and yellowness (b*) with increasing carrot powder levels. Sensory evaluation revealed that cookies from treatment T3 achieved the highest overall acceptability, whereas T4 scored the lowest. **Conclusion:** Adding carrot powder to millet-based cookies affected their physical, color, and sensory qualities, with moderate addition (T3) being most preferred by panelists.

Key words: Color analysis, cookies, finger, pearl, physical properties, sensory

INTRODUCTION

Millets are not only naturally gluten-free but also rich in both macro- and micronutrients, such as vitamins, minerals, dietary fiber, and phenolic compounds, highlighting their substantial nutritional value.[1] India is the world's largest producer of millet with a share of 38.4% of the world's production.[2] These vital cereal grains are used for the preparation of various foods and beverages in developing countries.[3] Millets, such as pearl millet, finger millet, and sorghum, are gaining recognition as nutritious alternatives to conventional grains due to their high fiber content, essential amino acids, and antioxidant properties.[4] The food processing industry has advanced significantly with scientific and technological progress, continuously adopting global innovations.[5] However, confectionery items, though widely consumed, are typically high in energy but lack essential nutrients, making them less ideal for a balanced diet.[6] In perspective, millet nutrition contains complete proteins, phenolic compounds, flavonoids, prebiotic fiber, essential micronutrients, minerals, vitamins, and bioactive peptides from proteins that show antihypertensive, antidiabetic, and anticancer properties.[7] The mineral content can be improved by adding ingredients high in minerals, such as amaranth, buckwheat, or flaxseed flour.[8] Pearl millet has many health

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benefits, including iron, zinc, folate, and beta-carotene.[9] Incorporating finger millet into biscuit production could boost its consumption, given the widespread popularity of biscuits among all age groups in Nigeria.[10] Finger millet has gained attention in recent years due to its rich starch content, high levels of dietary fiber, and abundance of calcium and iron.[11] Due to nutritional and economic benefits, there is a gradual shift from wheat toward non-wheat alternatives such as finger millet.[12] Finger millet (*Eleusine coracana*), is a member of the millet family known as a Ragi ortamba.[13] Ragi shows several functional properties which include anti-bacterial, antioxidant, and antimicrobial antidiabetic.[14] Wheat (*Triticum aestivum* L.) is one major of the most important cereal crops around for the majority of world's populations.[15] An estimated 35% of the world's population depends on wheat as their main crop. More than two-thirds of the world's wheat is consumed for human consumption, while just a fifth is used for animal feed.[16] It is mostly composed of 75–80% carbohydrates, 9–18% protein, fiber, several vitamins (particularly B vitamins), calcium, iron, and a variety of macro- and micro-nutrients.[17] Carrot powder is rich in beta-carotene, dietary fiber, and natural pigments. Its inclusion in bakery products not only boosts nutritional value but also imparts a natural orange hue, enhancing the visual appeal of the product.[18] Its inclusion in bakery products can enrich their nutritional value and provide natural coloring, reducing the need for synthetic additives.[19] Cookies are that their popularity can be attributed to their ease of consumption, microbiological stability, affordability, and the wide range of available shapes and flavors.[20] Cookies are among the most widely enjoyed quick snacks.[21] Evaluation of physical properties and color characteristics of millet-based cookies enriched with carrot powder, comprehensive evaluation of these attributes is crucial for improving industrial utility and consumer appeal. During the 2025/2026 crop year, global pearl millet production was approximately 30.3 million tonnes, with India leading as the top producer, contributing about 41.5% (around 12.6 million tonnes) of the total output. The present study aimed to examine the physical properties, color characteristics, and sensory evaluation of millet-based cookies blended with carrot powder.

MATERIALS AND METHODS

Raw materials

The ingredient materials used to prepare cookies were wheat flour, pearl millet flour, finger millet flour, carrot powder, bakery fat, sodium bicarbonate, ammonia bicarbonate, emulsifying (lecithin), butylated hydroxyanisole, sugar, and sodium chloride, which were purchased from the local market in Modipuram Meerut. The experiment was conducted during the year 2024–2025 at Post Harvest technology, Sardar Vallabhbhai Patel University of agriculture and technology.

Instruments and equipment

Instruments and equipment's used in the developed and study were, sieve, electronic balance, cookies maker, tray dryer, baking oven, desiccators, water bath, Vernier caliper, and hunter color. Cookies ingredients are shown in Table 1.

Description

T_0 – Cookies made by 100% wheat flour
T_1 – 17.5% wheat flour, 40% pearl millet flour, 40% finger millet flour, and 2.5% carrot powder
T_2 – 25% wheat flour, 35% pearl millet flour, 35% finger millet flour, and 5% carrot powder
T_3 – 32.5% wheat flour, 30% pearl millet flour, 30% finger millet flour, and 7.5% carrot powder

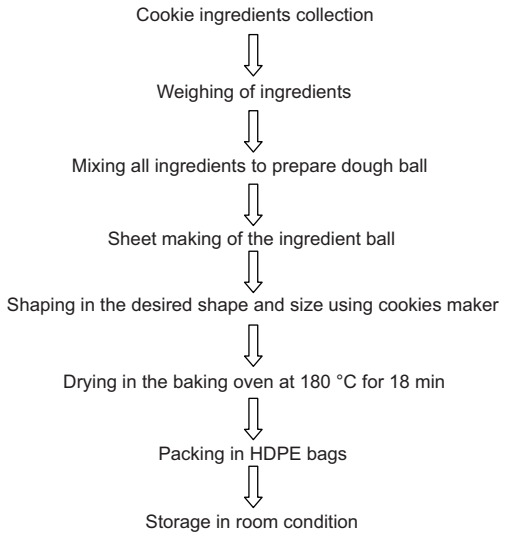
Table 1: Cookies ingredients

Process parameters	Treatment %				
	T_0	T_1	T_2	T_3	T_4
	WF100	WF17.5-PMF40-FMF40-CP2.5	WF25-PMF35-FMF35-CP5	WF32.5-PMF30-FMF30-CP7.5	WF40-PMF25-FMF25-CP10
WF (g)	300	52.5	75	97.5	120
PMF (g)	0	120	105	90	75
FMF (g)	0	120	105	90	75
CP (g)	0	7.5	15	22.5	30
Bakery fat (g)	75	75	75	75	75
Sodium bicarbonate (g)	3	3	3	3	3
Ammonia bicarbonate (g)	3	3	3	3	3
Emulsifying (Lecithin) (g)	3	3	3	3	3
NaCl (g)	45	45	45	45	45
BHA (Antioxidant) 200 ppm/g	0.6	0.6	0.6	0.6	0.6
Sugar (g)	150	150	150	150	150

WF: Wheat flour, PMF: Pearl millet flour, FMF: Finger millet flour, CP: Carrot powder, BHA: Butylated hydroxyanisole, NaCl: Sodium chloride

T_4 – 40% wheat flour, 25% pearl millet flour, 25% finger millet flour, and 10% carrot powder.

The detailed flow chart for the adopted method has been given below.



Source: Okaka and Isieh[22]

Physical properties analysis of cookies

Diameter of cookies was measured by laying five cookies edge to edge with the help of a scale rotating those 90° and again measuring the diameter of five cookies (cm) and then taking average value was half the measured using Vernier calipers.[23] Thickness was measured by stacking five cookies on top of each other and taking average thickness (cm), which was measured using Vernier calipers.[24] Weight of cookies (g) was measured as the average of values of five individual cookies with the help of a digital electronic weighing balance.[25] Spread ratio was calculated by dividing the average value of diameter by average value of thickness of cookies. The ratio between the diameter (cm) and the thickness (cm) was considered as the spread factor cookies.[23]

Color analysis of cookies

The value of the surface color of cookies was measured using Hunter Color a filter colorimeter (Brand, 3nH Colorimeter, model: NR60CP, China) which separates the components of reflected color into a three-dimensional color scale, method by Tong *et al*.,[26] Cookie color was measured at room temperature in terms of the L* (lightness), a* (redness), and b* (yellowness). Color scale views color in a similar manner to which the human eye sees color. Hunter L*, a*, b* color space is a three-dimensional rectangular color space based on opponent-colors theory. L* (lightness) axis (0–100) is black to white, and 50 is middle gray a* (redness) axis-positive values are red, negative values are green, and 0 is neutral b*(yellowness) axis-positive values are yellow, negative values are blue, and 0 is neutral.

Sensory evaluation of prepared cookies

Sensory evaluation of the millet-based cookies blended with carrot powder was carried out by a group of 20 panelists selected from the College of Post-Harvest Technology Department of Food Processing Laboratory at Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut, Uttar Pradesh, India. The judges evaluated the products using a nine point hedonic scale as described by score card,[27,28] which was using ranging where 9 = like extremely and 1 = dislike extremely. Faculty members and research scholar student panelists scored the sample for five sensory evaluations – color, taste, flavor, texture, and overall acceptability (OAA).

Statistical analysis

The experiments carried out in data were reported as mean±standard deviation for three replicates at least and analyzed using the one-way analysis of variance (ANOVA) and Duncan's multiple range tests at sig ≤−0.05 was used to determine significant differences between the mean values, ANOVA was performed using the Statistical Package for the Social Sciences software (IBM Statistical Analysis version 20.0). Microsoft Excel 7 was used to measure the mean and standard deviation of each experiment, which was carried out in triplicate.

RESULTS AND DISCUSSION

Physical properties analysis of cookies

This study determined the physical properties (diameter, thickness, weight, and spread ratio) of freshly baked cookies. The result of the physical properties of cookies developed process parameters of millets-based cookies blended with carrot powder is shown in Table 2. The diameter of the highest value in the cookies treatment T_2 sample is -5.74 cm, this occur due to presence of WF25% – PMF35% – FMF35% and CP5%, and the lowest value treatment T_4 sample is 5.53 cm in the presence of WF40% – PMF25% – FMF25% and CP10%. It ranged between highest thickness value of the cookies T_3 treatment sample 1.12 cm, in this presence of WF32.5% – PMF30% – FMF30% and CP7.5%, and the lowest value of 0.90 cm in the treatment T_4 sample WF40% – PMF25% – FMF25% and CP10%. The weight of cookies the highest value of T_3 sample 17.06 g in this presence of WF32.5% – PMF30% – FMF30% and CP7.5%, and lowest value of 12.71 g T_4 sample, this occur due to presence of WF40% – PMF25% – FMF25% and CP10%. The high value of spread ratio in cookies T_0 control sample 6.22, in this value only WF100%, and the lowest value of treatment T_3 sample

Table 2: Analysis of physical properties for cookies

Sample	Diameter (cm)	Thickness (cm)	Weight (g)	Spread ratio
T_0	5.73^{d}±0.008	0.92^{ab}±0.007	13.91^{b}±0.012	6.22^{de}±0.006
T_1	5.61^{b}±0.013	0.94^{b}±0.013	14.32^{bc}±0.009	5.96^{c}±0.014
T_2	5.74^{d}±0.019	1.07^{c}±0.014	15.52^{c}±0.010	5.36^{b}±0.013
T_3	5.66^{c}±0.018	1.12^{d}±0.016	17.06^{de}±0.012	5.05^{a}±0.015
T_4	5.53^{a}±0.015	0.90^{a}±0.021	12.71^{a}±0.010	6.14^{cd}±0.012

$P \leq 0.0$, Treatment along the column with different superscripts (a-e) differed significantly at $P \leq 0.05$. Each value represents the average of the three determinations±standard deviation

5.05 occurs due to the presence of WF32.5% – PMF30% – FMF30% and CP7.5%, respectively. According to Yamamoto *et al*.,[29] larger cookie spread ratio is considered a desirable quality attributes. The results reported by Makpoul and Ibrahim and Belorio *et al*.,[30,31] the details of the variation in physical properties of cookies for different treatments of millets based cookies blended with carrot powder are shown in Figure 1.

Description

T_0 – Cookies made by 100% wheat flour
T_1 – 17.5% wheat flour, 40% pearl millet flour, 40% finger millet flour, and 2.5% carrot powder
T_2 – 25% wheat flour, 35% pearl millet flour, 35% finger millet flour, and 5% carrot powder
T_3 – 32.5% wheat flour, 30% pearl millet flour, 30% finger millet flour, and 7.5% carrot powder
T_4 – 40% wheat flour, 25% pearl millet flour, 25% finger millet flour, and 10% carrot powder

Color analysis of cookies

Color is one of the most important quality attributes of a cookie product. The color attributes of made from cookie flour, wheat, pearl millet, finger millet, and blended with carrot powder, three was a considerable difference in color among different cookies samples which were measured and the result is showed in Table 3. The Hunter color parameters L* (lightness), a* (red-green), and b* (yellow-blue) are widely used to describe the color change of food materials. This result showed that the lightness (L*) value of cookies treatment T_0 control highest value was 55.52, and the lowest value of 36.10, treatment T_4 sample, the highest value of L* was found in T_0 this occurred due to only the presence of WF100%, and the lest value was seen in those made treatment T_4 using WF40% – PMF25% – FMF25% and CP10%. The redness (a*) high value was found in the cookies 14.58 treatment T_4 sample, in this presence of WF40% – PMF25% – FMF25% and CP10%, whereas the least value was 8.47 treatment T_2 sample of cookies in this occur due to the presence of WF25% – PMF35% – FMF35% and CP5%. The yellowness (b*) values were high in cookies T_4 treatment 45.91 made using

Table 3: Color analysis of cookies

Sample	L*-value (Lightness)	a*-value (redness)	b*-value (yellowness)
T_0	55.52^{e}±0.007	12.14^{d}±0.015	44.85^{d}±0.008
T_1	46.54^{d}±0.015	8.64^{ab}±0.014	30.69^{a}±0.005
T_2	41.39^{b}±0.012	8.47^{a}±0.012	33.10^{b}±0.006
T_3	44.57^{c}±0.014	10.33^{c}±0.008	35.34^{c}±0.009
T_4	36.10^{a}±0.010	14.58^{e}±0.010	45.91^{de}±0.003

$^{**}P \leq 0.01$, Treatment along the column with different superscripts (a-e) differed significantly at $^{*}P \leq -0.05$. Each value represents the average of the three determinations±standard deviation

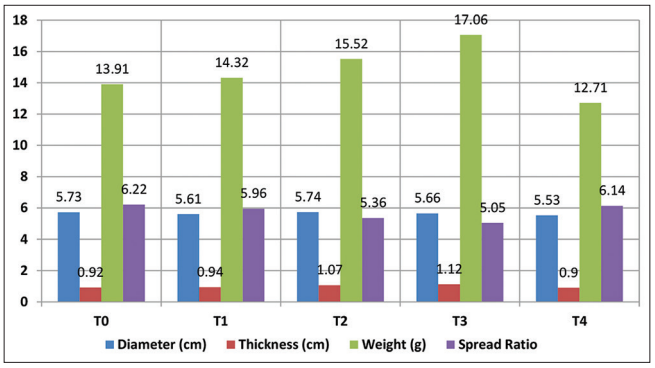


Figure 1: Variation in physical properties of cookies for different treatments

WF40% – PMF25% – FMF25% and CP10%, and the lowest value sample T_1 control 30.69 in this occurs due to only the presence of WF17.5% – PMF40% – FMF40% and CP2.5%. The result was lightness, redness, and yellowness, of cookies made from flour, wheat, pearl millet, finger millet, and blended with carrot powder. The results were in accordance's with,[32-34] the details of the variation in color of cookies for different treatments of millets based cookies blended with carrot powder are shown in Figure 2.

Sensory evaluation of prepared cookies

The results of sensory evaluation revealed that millet-based cookies blended with carrot powder samples in fresh condition were rated between color (7.7–8.2), taste (8.5–8.8), flavor (7.7–8.8), and texture (8.0–8.7) [Table 4],

Table 4: Sensory evaluation of the cookies

Sample	Color	Taste	Flavor	Texture	Overall acceptability
T_0	8.2±0.19	8.5±0.52	7.7±0.51	8.2±0.45	8.1±0.39
T_1	7.9±0.34	8.6±0.65	8.3±0.64	8.3±0.69	8.3±0.49
T_2	7.8±0.71	8.7±0.71	8.4±0.61	8.5±0.59	8.4±0.55
T_3	8.1±0.56	8.8±0.68	8.8±0.58	8.7±0.45	8.6±0.56
T_4	7.7±0.51	8.5±0.65	7.8±0.58	8.0±0.24	8.0±0.51

*$P \leq 0.05$ each value represents the average of the three determinations±standard deviation

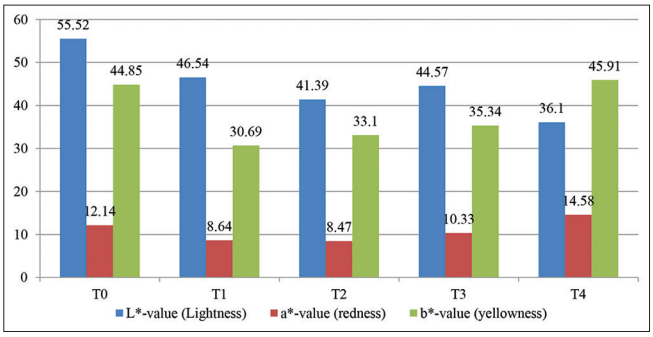


Figure 2: Variation in color of cookies for different treatments

respectively. It is also important to note that the OAA of these cookies was 8.1, 8.3, 8.4, 8.6, and 8.0, respectively, in fresh condition. The samples T_3 were the highest scores which occur due to 32.5% wheat flour, 30% pearl millet flour, 30% finger millet flour, and 7.5% carrot powder by the panelist, compares the lowest scores sample T_4 due to occur 40% wheat flour, 25% pearl millet flour, 25% finger millet flour, and 10% carrot powder.[27] Thus, on the OAA score, sample T_3 was considered as standardized and can be used for further supplementation.

CONCLUSION

The incorporation of carrot powder into millet-based cookies significantly influenced their physical properties, color characteristics, and sensory attributes. Among the samples, T3 (with moderate carrot powder inclusion) exhibited the most desirable qualities in terms of thickness, weight, and sensory acceptability, while T4 showed the least favorable results. This suggests that a balanced proportion of carrot powder and millet flour can enhance cookie quality, both nutritionally and organoleptically.

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