Evaluating the Impact of Compound Milk Chocolate Enrobing on Butter Cookies: A Physicochemical and Sensory Assessment

ABSTRACT

Chocolate enrobing significantly enhances the quality of cookies by enriching flavour, retaining moisture, improving visual appeal and extending shelf life. This study focused on assessing the impact of chocolate enrobing on the physicochemical and sensory properties of butter cookies. The enrobing process was performed using a laboratory-scale chocolate enrobing machine developed by the Department of Processing and Food Engineering at Kelappaji College of Agricultural Engineering and Food Technology, located in Tavanur, Malappuram, Kerala. Engineering characteristics of compound milk chocolate, such as bulk density, viscosity and proximate composition, were analyzed. Physicochemical attributes of butter cookies both before and after enrobing were also assessed. The results revealed an increase in the fat, protein, fiber and ash content in the chocolate enrobed cookies compared to the uncoated butter cookies. The enrobing ratio of cookies coated with compound milk chocolate was determined to be 76%. Furthermore, the energy content of the cookies increased significantly, rising from 487.17 to 497.88 kcal ($p = 0.012$), indicating an improvement in their nutritional profile. Sensory analysis demonstrated that chocolate-enrobed cookies were preferred in terms of colour, appearance, taste, flavour and overall acceptability, showcasing the benefits of enrobing.

What specific sample is recommended and rated higher in terms of sensory and physicochemical attributes

Keywords: Butter cookie, compound milk chocolate, enrobing, physicochemical properties, sensory analysis.

1. INTRODUCTION

Cookies have become a popular snack choice among consumers due to their diverse shapes and sizes, high digestibility, energy value, affordability, convenience and long shelf life (Sławińska et al., 2024). Among various types, butter cookies stand out with their rich, buttery taste and crumbly texture, a tradition that traces back to Denmark. Butter cookies made with an ingredients viz. butter, sugar, flour, egg and vanilla for flavouring. When baked to a golden brown, these cookies boast a crispy exterior and a crumbly, soft interior, delivering a satisfying crunch and heightened flavour. **Reference**

Food producers are driven by consumer demand to improve the nutritional and sensory qualities of their products. Enhancing the nutritional and sensory qualities of butter cookies through the chocolate enrobing process offers a valuable way to elevate these classic treats. Enrobing butter cookies with chocolate is a process in which a layer of melted chocolate is applied to the surface of the cookies. This process involves passing the cookies through a curtain of liquid chocolate, covering them evenly as they travel on a conveyor belt. Excess chocolate to be removed by a stream of hot air to ensure a uniform coating and the enrobed cookies are then cooled to allow the chocolate to set and harden (Talbot, 2009). Butter cookies, with their blend of rich texture, buttery flavour and simplicity are particularly well-suited for chocolate enrobing. The smooth, luscious chocolate coating complements the crumbly, delicate texture of the butter cookies, delivering a delightful mouth feel. The butter content intensifies the flavour experience, creating a satisfying soft bite, while the cookies structural integrity ensures they maintain their shape throughout the enrobing process.

Reference

Reference

Enrobing process enhances the sensory appeal of butter cookies, creating a delightful contrast between the smooth, rich chocolate layer and the crumbly, buttery cookie base. The enrobing process also contributes to improved product stability by providing a moisture barrier, thus extending shelf life while maintaining the freshness, crunch and overall appeal of the cookies (Brown,2009). This makes the enrobed butter cookies not only more flavourful but also visually appealing and more resistant to environmental factors like humidity. Nutritionally, incorporating chocolate with higher cocoa content increases the fiber and essential mineral levels in the final product.

The main components of chocolate include cocoa liquor, cocoa butter, sugar, emulsifiers and milk powder (Li et al., 2014; Afoakwa et al., 2007). The varying levels of cocoa solids, milk fat and cocoa butter define the primary types of chocolate: dark, milk and white (Konar et al., 2016). Cocoa butter, derived as a by-product from mature cocoa beans of the *Theobroma cacao* plant, is an essential ingredient in chocolate and various confectionery items. However, due to increasing demand, limited availability, inconsistent harvest quality, economic factors and specific technological advantages, cocoa butter alternatives (CBAs) have been developed. These fats are designed to either partially or fully substitute cocoa butter (Hussain et al., 2018). CBAs are sourced from ingredients like shea butter, palm oil and others. CBAs help alleviate cocoa butter shortages and provide functional benefits in chocolate manufacturing (Naik and Kumar, 2014).

Compound chocolate, often used for enrobing contains fats such as modified palm kernel oil or coconut oil, which have been modified to mimic melting properties of cocoa butter. This alternative is favoured for its cost-effectiveness and ease of handling, as it does not require tempering. Unlike regular chocolate, compound chocolate sets quickly, creating a stable and glossy finish. It also has favourable melting and solidification traits, ensuring a consistent coating on products like cookies and a greater resistance to heat, thereby reducing the risk of bloom-a white, chalky surface. The use of vegetable fats lends compound chocolate a higher melting point than traditional chocolate, typically melting between 35°C and 40°C. This property makes compound chocolate ideal for enrobing, offering superior structure retention and resistance to melting under varying temperature conditions. The aim of the present research was to estimate the impact of chocolate enrobing on the physico-chemical and sensory properties of butter cookies.

2. MATERIALS AND METHODS

2.1 Procurement of raw materials

The main raw materials used are butter cookies and compound milk chocolate as enrobing material. Compound milk chocolates were procured from the chocolate firm at Kodaikanal, Dindigul district, Tamilnadu. Butter cookies were purchased from the local market Tavanur, Malappuram district, Kerala. Chocolates were stored in the laminated aluminium pouch and refrigerated at 4°C until used. Cookies were stored in an air tight container at room temperature.

2.2 Determination of Engineering properties of compound milk chocolate

The engineering properties of chocolate such as bulk density, moisture content, protein, ash, fiber and fat were determined by using methods as described in AOAC (2005). The carbohydrate content was calculated by subtracting the values for moisture, protein, ash, fiber and fat from 100. Water activity of chocolate was determined by using Aqua lab water activity meter (M/s Aqua lab, Decagon device Inc., Pullman, USA). The energy content of the sample is the energy released from carbohydrates, fats, proteins and other organic compounds. It is an important parameter deciding the nutritive value of food. Energy content of food was computed from the available nutrient information of food components viz. protein, carbohydrate and fat content using formula given by Gopalan *et al*. (1989). The formula is shown by Eqn. 1.

Energy (kcal) = (4 x Protein) + (4 x Total carbohydrates) + (9 x Fat) ……Eqn. 1

2.2.1 Determination of flow behaviours of compound milk chocolate

Rheological Measurements were performed at 40°C using a controlled stress– strain rheometer (MCR 52, Anton Paar, Ostfildern, Germany) to determine the flow behaviour of chocolate samples. The chocolate melted at 40°C was put into the chocolate cell of the rheometer and the sample was pre-sheared at 5 s^{-1} for 500 s in order to complete homogenization. Then, a varied shear rate profile was applied by applying increasing the shear rate from 2 s^{-1} to 50 s^{-1} for 180 s, stable shear rate at 50 s^{-1} for 60 s and reducing the shear rate from 50 s^{-1} to 2 s^{-1} for 180 s, corresponding to each shear rate profile 18, 6 and 18 measurements were taken respectively. The yield stress and plastic viscosity behaviours of samples were analysed by using the Casson model based on the following Eqn. 2.

$$\sqrt{\tau} = \sqrt{\tau_0} + \sqrt{\eta_{pl}}\sqrt{\dot{\gamma}}$$ ……..Eqn.2

where, τ is shear stress, τ_0 is yield stress, η_{pl} is Casson plastic viscosity and γ is shear rate (Ertural et al., 2023).

2.3 Physicochemical properties of cookies

2.3.1 Physical characteristics

How many samples were randomly selected?

The cookies were randomly selected and the weight of each cookie was measured with a digital top-loading balance (CONTECH), capable of recording weights in grams and milligrams. Their thickness and diameter were measured with a digital caliper (ACCU plus), both before and after enrobing and repeating the process five times. The average of the five measurements were taken as the final diameter and thickness of the cookie. The spread ratio was calculated using the formula: diameter of cookies divided by thickness of cookies (Sławińska et al., 2024).

2.3.2 Chemical analysis

The chemical composition analysis involved determining moisture content, protein, ash, fiber and fat by using methods as described in AOAC (2005). The carbohydrate content was calculated by subtracting the values for moisture, protein, ash, fiber and fat from 100. Water activity of cookies were determined by using Aqua lab water activity meter (M/s Aqua lab, Decagon device Inc., Pullman, USA). The energy value of chocolate was calculated by using the Eqn. 3

2.4 Enrobing process

The cookie enrobing process was carried out using a laboratory-type chocolate enrobing machine designed by Department of Processing and Food Engineering at Kelappaji College of Agricultural Engineering and Food Technology, Tavanur, Malappuram, Kerala. Flow rate of chocolate, belt speed and flow rate of hot air of the enrobing machine were adjusted as per the requirement. After enrobing, the samples were subjected to hot air flow to remove excess chocolate from their surface. Finally, the enrobed cookie samples were placed in a freezer at 8 to 12°C for 15 minutes, after which all samples were packed in laminated aluminum pouches and stored in a refrigerator at 4°C.

2.5 Determination of chocolate enrobing ratio of cookies

The mass difference of the cookies before and after the enrobing process was divided by the initial mass value in order to determine the enrobing ratio (%) (Ertural et al., 2023). Enrobing ratio was calculated by using Eqn.3.

Enrobing ratio = $\frac{m_2 - m_1}{m_1} \times 100$ … Eqn.3.

where m_1 = Pre-enrobing cookie mass (g)
m_2 = Post-enrobing cookie mass (g)

2.6 Colour analysis

The colour properties of melted compound milk chocolate, butter cookies and compound milk chocolate enrobed cookie samples were determined with a Lovibond Tintometer. The L* (brightness), a* (redness-greenness) and b* (yellowness-blueness) values, as well as the chroma (C*) and hue angle (°h) values of the samples were determined. The dimension L* means lightness, with 100 for white, 0 for black; a* indicates redness when positive and greenness when negative, b* indicates yellowness when positive and blueness when negative. The parameter ΔE was calculated by using Eqn.4 (Sławińska et al., 2024).

$$\Delta E = [(L^{*}\text{sample} - L^{*}\text{control})^{2} + (a^{*}\text{sample} - a^{*}\text{control})^{2} + (b^{*}\text{sample} - b^{*}\text{control})^{2}]^{1/2}$$ ….Eqn.4

2.7 Sensory analysis

Sensory evaluation of cookies were done using a nine-point hedonic scale based on the appearance, colour, taste, flavour, crispiness and overall acceptability. For the evaluation of sensory attributes of cookies, 20 members were selected from the Department of Processing and Food Engineering, Kelappaji College of Agricultural Engineering and Food Technology, Tavanur, Kerala Agricultural University, Malappuram district, Kerala.

2.8 Statistical analysis

Quintuplicate analysis of the data was done using IBM-SPSS (International business machines-statistical package for social sciences) 23 version software. The analyzed data were expressed as mean with standard deviation (SD). Paired sample t-test was done to identify significant differences at the significance level of $P<.05$ between the mean values of the two samples.

3. RESULTS AND DISCUSSION

3.1 Engineering properties of chocolate

The engineering properties of chocolate, including bulk density, viscosity, moisture content and water activity were assessed using standard methods and are presented in Table 1. The measured values for bulk density, moisture content and water activity were 1228 ± 0.08 kg/m^3, 1.28 ± 0.32% and 0.46 ± 0.03, respectively. The fat, protein, ash, fiber and carbohydrate contents of the chocolate were determined to be 30.69 ± 0.97%, 11.32 ± 0.08%, 1.402 ± 0.01%, 0.74 ± 0.08% and 54.56 ± 0.68%, respectively. Additionally, the energy value of the compound milk chocolate was calculated as 539.73 ± 3.42 kcal.

3.1.1 Determination of flow behaviours of compound milk chocolate

Casson model is a well-known and the most used rheological model for describing the non-Newtonian flow behaviour of fluids with a yield stress. From this model, casson yield value describes the stress needed to start the flow and casson viscosity assesses internal friction during the flow are derived (Cahyani et al., 2019). Some fluids are particularly well described by this model because of their nonlinear yieldstress - pseudoplastic nature and chocolate is one among those fluids. The effect of shear rate on viscosity of chocolate is shown in Fig.1. Viscosity vs shear rate curve generally used to identify the rheological behaviour of chocolate such as shear thinning (pseudoplastic) or shear thickening (dilatant). From the Fig.1. it is shown that viscosity decreases with increase in shear rate, which proved a pseudoplastic or shear thinning behaviour of chocolate.

Table 1. Engineering properties of compound milk chocolate

Engineering property	Value
Bulk density (kg/m^3)	1228 ± 0.08
Moisture content % (wb)	1.28±0.32
Water activity	0.46 ±0.03
Apparent Viscosity (Pa.s)	3.82 ± 0.02
Casson plastic viscosity (Pa.s)	2.34 ± 0.04
Yield stress (Pa)	6.9 ± 0.03
Fat content (%)	30.69+0.97
Ash content (%)	1.402+0.01
Fiber content (%)	0.74 ±0.08
Protein (%)	11.32 ± 0.08
Carbohydrate (%)	54.56 ± 0.68
Energy (kcal)	539.73 ± 3.42

Milk compound chocolates indicated a shear thinning behaviour and the viscosity of chocolate was found to be 3.82 Pa.s. By using casson model, casson plastic viscosity and yield stress value of chocolate was determined as 2.34 Pa.s and 6.9 Pa respectively. The viscosity of chocolate indicates how resistant it is to flow under the applied shear conditions during enrobing. A value of 3.82 Pa.s suggested that the chocolate has moderate resistance to flow and has the perfect flow characteristics for an even and controlled coating over the cookies. It is fluid enough to coat the cookies smoothly but thick enough to ensure a consistent and high-quality finish.

The yield stress indicates the minimum force required to initiate flow. A yield stress of 6.9 Pa indicates that chocolate will hold its form better, making it less likely to drip or spread too thinly on the cookies. During enrobing, this allow for a more controlled application where the chocolate adheres well but does not run off.

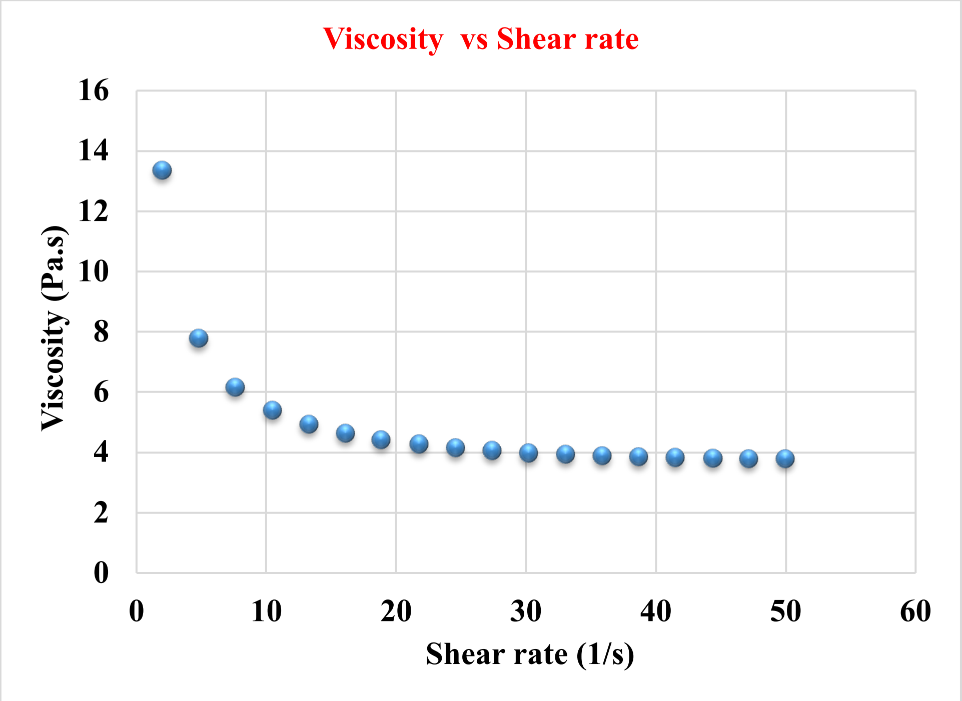

Fig.1. Effect of shear rate on viscosity of chocolate

The Casson plastic viscosity is typically used to characterize the flow behaviour of materials that exhibit yield stress like chocolate. A value of 2.34 Pa.s for plastic viscosity indicates that once the yield stress is surpassed, the chocolate flows at a moderate rate. Chocolate will only start to flow when subjected to a shear stress greater than its yield stress (6.9 Pa). This is typical for chocolates that require a certain amount of force or heating to flow. In the enrobing process, the chocolate needs to be heated enough to reduce its viscosity to allow for smooth enrobing.

3.2 Physicochemical analysis of cookies

3.2.1 Physical properties of cookie and enrobed cookie

The results of basic composition including water activity and moisture content of the cookie and enrobed cookie are shown in table 2. A recent study showed that enrobing the cookies with chocolate increase the weight, diameter and thickness of the cookie from 11.90 ± 0.39 to 20.97 ±0 .08 g, 5.05 ± 0.02 to 5.22 ± 0.03 cm and 13.73 ±0 .09 to 16.52 ± 0.03 mm significantly with significance level of ($p < .05$).

It was found that the mean coating thickness of chocolate over the cookie is 2.79 mm. The coating thickness values obtained in this study are consistent with coating thicknesses ranges between 1.1 to 2.7 mm found in similar research conducted by Wichchukit et al. (2006). This suggests that the results align with previously observed trends in coating thickness, supporting the reliability of the findings in the context of chocolate-coated cookies.

Table 2. Basic composition of cookies and enrobed cookies

How many of each of the samples gave this result?

Perform post-hoc test and include letters

Type of cookie	Weight (g)	Diameter (cm)	Thickness (mm)	Spread ratio	Water activity	Moisture content (%)
Cookie	11.90 ± 0.39	5.05 ± 0.02	13.73 ±0.09	3.68 ± 0.03	0.32 ± 0.02	2.04 ± 0.08
Enrobed cookie	20.97 ±0 .08	5.22 ± 0.03	16.52 ± 0.03	3.16 ± 0.02	0.41 ± 0.01	2.82 ± 0.06

The addition of compound milk chocolate during the enrobing process leads to an increase in the mass of cookies, altering their physical properties and enhancing sensory qualities such as texture and perceived richness. Although there is a minor increase in diameter, due to the layering of chocolate and slight heat exposure, its overall effect remains minimal. On the other hand, the notable increase in thickness highlights the consistent and uniform application of the coating, which impacts texture, enhances the sense of indulgence, and improves overall product quality.

The spread ratio parameter describes the shape and quality of cookies (Sławińska et al., 2024).. The reduction in spread ratio from 3.68 ± 0.03 to 3.16 ± 0.02 for enrobed cookies compared to plain cookies indicates that the chocolate coating limits their lateral expansion, providing greater structural stability during application and cooling. Significant ($p < .05$) differences were noted between the results.

The total moisture content and water activity of cookies and chocolate enrobed cookies were observed to be increased significantly ($p<.05$) from 2.04 ± 0.08 to 2.82 ± 0.06% and 0.32 ± 0.02 to 0.41 ± 0.01 due to the presence of the chocolate coating, which could create a barrier effect that slows down moisture loss or absorbs moisture from the surrounding environment, slightly elevating the overall moisture content and water activity. Kumar et al. (2021) reported that the moisture content of the product increases due to the associated characteristics of applied coating ingredients. A water activity of 0.60 to 0.65 is generally considered safe for cookies, including those with coatings. For cookies, moisture content should be kept under 10% to maintain quality, prevent staling and limit microbial growth. For coated cookies, especially those with chocolate, moisture content should ideally be below 5%.

3.2.2 Chemical analysis

The proximate compositions of cookies and chocolate enrobed cookies are compared as shown in Table 3. The total percentage of the fat content of cookies after enrobing was found greater than cookie before enrobing and varied from 19.78 ± 0.57 to 22.94 ± 0.78%($p=.04$). The increase in the fat content is attributed to the additional layer of compound milk chocolate, which typically contains a higher proportion of fats (30.69%). The protein, fiber, and ash contents were also found to increased from 6.78 ± 0.08 to 9.45 ± 0.05%, 0.24 ± 0.03 to 0.43 ± 0.03% and 0.67 ± 0.04 to 0.99 ± 0.04%, respectively ($p<.05$). Increase in other nutrients in chocolate enrobed cookies has resulted in the lowering of carbohydrate content from 70.50 ± 0.67 to 63.37 ± 0.79%. The energy content of the enrobed cookies (497.77 ± 3.76 kcal) was higher than that of cookies (487.17 ± 2.46 kcal). This increase is consistent with the elevated fat and protein content, which contribute more calories compared to carbohydrates ($p= .012$). These results indicate a statistically significant difference ($p<.05$) in the nutritional values between the cookies before and after enrobing, consistent with findings from Kumar et al. (2021).

Table 3. Proximate compositions of cookies and enrobed cookies

Type of cookie	Fat (%)	Protein (%)	Fiber (%)	Ash (%)	Carbohydrate (%)	Energy (kcal)
Cookie	19.78 ± 0.57	6.78 ± 0.08	0.24 ± 0.03	0.67 ± 0.04	70.50 ± 0.67	487.17 ± 2.46
Enrobed cookie	22.94 ± 0.78	9.45 ± 0.05	0.43 ± 0.03	0.99 ± 0.04	63.37 ± 0.79	497.77 ± 3.76

3.3 Enrobing ratio of cookie samples

The enrobing ratio was detected as 76 % in the sample enrobed with compound milk chocolate. A 76% enrobing ratio indicates good coverage, this provides a satisfying balance between the cookie and the chocolate, ensuring that the coating is thick enough to deliver a rich taste but not so thick that it overwhelms the cookie. This balance will lead to a high-quality, attractive product that is sure to meet consumer expectations.

3.4 Colour analysis

The surface colour characteristics of the cookies and the enrobed cookies (Fig. 2) were given in Table 4. In this study, the L* value, representing lightness, showed a significant decrease in value (P < .05). Cookies exhibited a higher L* value of 59.26 ± 0.62, indicating a pale, golden hue, whereas the enrobed cookies had a lower L* value of 37.02 ± 0.77, reflecting a darker, richer colour due to the chocolate coating. The a* value, associated with the red-green axis, decreased slightly from 14.88 ± 0.66 to 13.34 ± 0.36 due to the chocolate's brownish-red colour (P =.001). Furthermore, the b* value, representing the yellow-blue axis, also showed a significant decrease (P < .05) for enrobed cookies.

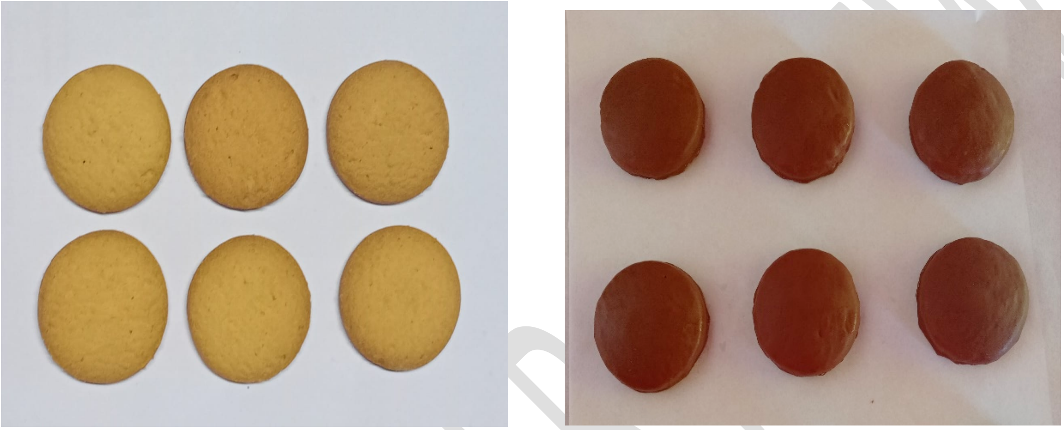

Fig.2. Cookie and chocolate enrobed cookie

A similar trend was observed for chroma (C*) and hue angle (°h) values, indicating a notable change in colour intensity and tone. The colour difference (ΔE) of 30.33 ± 0.01 between the cookies and enrobed cookies highlights a substantial visual transformation resulting from the enrobing process.

Table 4. Colour properties of cookie samples

Type of cookie	L^*	a^*	b^*	c^*	°h	ΔE
Cookie	59.26± 0.62	14.88 ± 0.66	33.24 ± 0.58	36.28 ± 0.41	66.32 ± 1.24	
Enrobed cookie	37.02 ± 0.77	13.34 ± 0.36	12.68 ± 0.36	17.82 ± 0.61	46.66 ± 1.41	30.33 ± 0.01

3.5 Sensory analysis

Sensory evaluation results are given in table 5. Appearance, colour, taste, flavour, crispiness and overall acceptability scores of cookies and enrobed cookies were varied from 8.10 ± 0.22 to 8.80 ± 0.45, 7.80 ± 0.45 to 8.60 ± 0.55, 7.70 ± 0.67 to 8.90 ± 0.22, 7.80 ± 0.45 to 8.60 ± 0.55, 8.80 ± 0.45 to 8.40 ± 0.55 and 8.20 ± 0.45 to 8.90 ± 0.22, respectively. According to the sensory analysis results, the cookies enrobed with compound milk chocolate had high appreciation in terms of appearance, colour, taste and overall acceptability (p=.02). This is consistent with a study by Gounga et al. (2017), which also reported improved sensory properties due to coating. The chocolate coating showed a statistically significant difference in the crispiness of the cookies (p= .37). Furthermore, the sensory analysis revealed a significant positive relationship between cookies.

Table 5. Sensory analysis of cookie samples

Type of cookie	Appearance	Colour	Taste	Flavour	Crispiness	Overall acceptability
Cookie	8.10 ± 0.22	7.80 ± 0.45	7.70 ± 0.67	7.80 ± 0.45	8.80 ± 0.45	8.20 ± 0.45
Enrobed cookie	8.80 ± 0.45	8.60 ± 0.55	8.90 ± 0.22	8.60 ± 0.55	8.40 ± 0.55	8.90 ± 0.22

4. CONCLUSION

This study evaluated the physicochemical properties of chocolate and butter cookies. The flow behaviour of compound milk chocolate, used as an enrobing material, was also analyzed and its impact on the primary quality attributes of the final product was examined. The results revealed that chocolate enrobing enhanced the fat, protein, fiber and ash content of the cookies which demostrated an increase in the nutritional values of chocolate-enrobed cookies. Sensory evaluation indicated superior results for chocolate-enrobed cookies, particularly in terms of colour, appearance, taste and flavour. The comparison between the cookies before and after enrobing showed a significant ($p<.05$) improvements in sensory and quality parameters. Addition of a chocolate coating effectively enhanced the textural, sensory and nutritional properties of the cookies.

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