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

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Enrobing is a process where confections or snacks are coated with a layer of chocolate or a chocolate-based coating. This technique significantly enhances snacks quality by improving flavour, retaining moisture, improving visual appeal and extending shelf life. The present study investigated the effects of chocolate enrobing on the physicochemical and sensory properties of butter cookies. The enrobing process was carried out using a laboratory-scale chocolate enrobing machine

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developed under the Department of Processing and Food Engineering of Kelappaji College of Agricultural Engineering and Food Technology, Tavanur, Malappuram district, Kerala. Engineering properties of compound milk chocolate such as bulk density, viscosity and proximate composition were evaluated as per the standard procedures. Additionally, the physicochemical properties of butter cookies were analysed before and after the enrobing process. The results revealed significant improvements (p<.05) in the nutritional composition of chocolate enrobed cookies compared to base butter cookies. Specifically, fat, protein, fiber and ash content of chocolate enrobed cookies increased by 15.98%, 39.38%, 79.17% and 47.76%, respectively over the base cookies. Furthermore, the energy content of the enrobed cookies increased from 487.17 kcal to 497.88 kcal, reflecting a 2.18% enhancement in their overall nutritional profile. The enrobing ratio for cookies coated with compound milk chocolate was found to be 76%. Sensory evaluation results showed that chocolate enrobed cookies were highly favoured for their colour, appearance, taste, flavour and overall acceptability, demonstrating the benefits of enrobing process. The findings indicated that chocolate enrobed butter cookies, with their enhanced sensory appeal, superior physicochemical properties and improved nutritional value are an excellent choice for both consumer satisfaction and commercial viability.

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). A standard cookie recipe usually includes wheat flour, icing sugar, butter and eggs as the main ingredients. The process of making cookies can generally be divided into three stages: mixing, moulding and baking. Among these, baking plays a vital role, as it transforms the dough into a flavourful snack with a light, porous texture due to the heat (Hu et al., 2022). Commercial cookies are typically made from refined wheat flour, which is low in protein. Refined wheat flour contains about 10% protein and is deficient in lysine and essential amino acid (Timbadiya et al., 2017). At present, numerous scientific studies, both domestic and international are focused on developing pastry products, including butter cookies, with improved nutritional value (Sokol et al., 2021).

Products like wafers or cookies can be coated with chocolate or compound coatings. Chocolate enrobing enhances these products by elevating their visual appeal and enriching their flavour with a luxurious, indulgent taste (Sundara et al., 2014). Butter cookies, with their blend of rich texture, buttery flavour and simplicity are particularly well-suited for chocolate enrobing. 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).

The main components of chocolate include cocoa liquor, cocoa butter (CB), 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 help alleviate cocoa butter shortages and provide functional benefits in chocolate manufacturing (Naik and Kumar, 2014).

Compound chocolate is generally used for coating different food products such as cookie, cake, candy, wafer and different dried nuts such as roasted chickpea and almond (Toker et al., 2016). 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. Cocoa Butter Substitutes (CBS) fats come usually from coconut or palm kernel oils. These fats are usually hydrogenated or fractionated to increase their hardness and to improve their melting profile. CBS replaces the totality of CB in a coating, except for the CB that is present in cocoa powder (Naik and Kumar, 2014). 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 (Sundara et al., 2014). Higher CBS in milk chocolate required a longer time to melt than pure milk chocolate that has fully CB (Hussain et al., 2018). Additionally, Hussain et al. (2018) identified a eutectic effect in CB and CBS mixtures, with the end melting temperature ranging between 40°C and 45°C. The use of vegetable fats lends compound chocolate a higher melting point than traditional chocolate. This property makes compound chocolate ideal for enrobing, offering superior structure retention and resistance to melting under varying temperature conditions.

By incorporating a thin chocolate coating, it becomes possible to create innovative products that blend the traditional flavours of butter cookies with the richness of chocolate, offering a unique and appealing snack option (Ertural et al., 2023). Enrobing proces 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).

The aim of the present research is to estimate the impact of chocolate enrobing on the physicochemical 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 content 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.

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

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 Base Cookies and Chocolate Enrobed Cookies

2.3.1 Physical characteristics of base cookies and chocolate enrobed cookies

Five 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. The thickness and diameter of each cookie were measured with a digital calliper (ACCU plus), before and after the enrobing process. The spread ratio was calculated using the formula: diameter of cookies divided by thickness of cookies (Sławińska et al., 2024). Average of five measurements were taken as the final measurement of the cookie.

2.3.2 Chemical analysis of base cookies and chocolate enrobed cookies

The chemical composition analysis involved determining moisture content, protein, ash, fiber and fat content by using standard 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 cookies were calculated by using Eqn.1

2.4 Preparation of Samples by Enrobing Process

Enrobing process was carried out using a laboratory-scale chocolate enrobing machine developed under Department of Processing and Food Engineering of Kelappaji College of Agricultural Engineering and Food Technology, Tavanur, Malappuram district, Kerala. The purchased butter cookies served as the base product, while the compound milk chocolate used as the enrobing material was melted by double boiling method in the enrobing machine at 35 to 40°C, to achieve a smooth and consistent chocolate flow. Flow rate of chocolate, belt speed and flow rate of hot air of the enrobing machine were adjusted as per the requirement. The cookies were placed on the moving belt of the enrobing machine, where a continuous sheet of molten chocolate coated the cookies as they passed beneath the coating system, ensuring an even layer of chocolate covered their entire surface. After enrobing, a sheet of hot air was applied to remove excess chocolate from their surface. Then the enrobed cookie samples were placed in a freezer at 8 to 12°C for 15 minutes to cool and solidify the chocolate layer. The cookies were coated on both sides separately by first passing them through the machine to coat the bottom, followed by a second pass to coat the top. Finally, the samples were packed in laminated aluminium 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.

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

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 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 and 0 for black, a* indicates redness when positive and greenness when negative, b* indicates yellowness when positive and blueness when negative. The parameter ∆E was calculated by using Eqn.4 (Sławińska et al., 2024).

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

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 of Kelappaji College of Agricultural Engineering and Food Technology, Tavanur, Kerala Agricultural University, Malappuram district, Kerala.

2.8 Statistical Analysis

Statistical analysis was performed using RStudio (version 2024.9.1.0) software. The one-way analysis of variance (ANOVA) was employed while the significant differences were established using Tukey HSD post-hoc test. A level of significance of p<.05 was used throughout the analysis. All data were presented as mean values ± standard deviation (SD).

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 evaluated using standard methodologies and are presented in Table 1. The bulk density, moisture content and water activity of the chocolate were recorded as 1228 ± 0.08 kg/m³, 1.28 ± 0.32% and 0.46 ± 0.03, respectively. The chocolate also contained 30.69 ± 0.97% fat, 11.32 ± 0.08% protein, 1.402 ± 0.01% ash, 0.74 ± 0.08% fiber and 54.56 ± 0.68% carbohydrate, with an energy value of 539.73 ± 3.42 kcal. When compared to previous findings, Wichchukit et al. (2006) reported a bulk density of 1270 kg/m³ for milk chocolate melts, which is slightly higher than the value (1228 ± 0.08 kg/m³) observed in this study. This variation may arise from differences in formulation or processing conditions. The moisture content in this study (1.28 ± 0.32%) is remains within the acceptable limit of less than 1.5%, as noted by Haniyeh et al. (2017).

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. Some fluids are particularly well described by this model because of their nonlinear yieldstress - pseudoplastic nature and chocolate is one among those fluids (Cahyani et al., 2019). Chocolate rheology is generally quantified in manufacturing processes using two parameters: yield stress and plastic viscosity. Yield stress is a material property which defines the transition from elastic to viscous deformation. Plastic viscosity determines pumping characteristics, filling of rough surfaces, coating and sensory character of chocolate mass (Akdeniz et al. 2021).

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. These findings are consistent with the observations of Akdeniz et al. (2021), reporting that milk compound chocolates exhibited shear thinning behaviour.

The use of enrobing technology is prevalent in the chocolate manufacturing industry. The molten chocolate or chocolate coating flows in a sheet above a moving belt. The product is coated as it moves through the sheet. For good quality and accurate weight control, the chocolate must have the correct viscosity (Aeschlimann and Beckett, 2000).

Table 1. Engineering properties of compound milk chocolate

Engineering property	Value
Bulk density (kg/m³)	1228 ± 0.08
Moisture content % (wb)	1.28±0.32
Water activity	0.46 ±0.03
Apparent Viscosity (Pa.s)	3.69 ± 0.02
Casson plastic viscosity (Pa.s)	2.28 ± 0.04
Yield stress (Pa)	6.43 ± 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

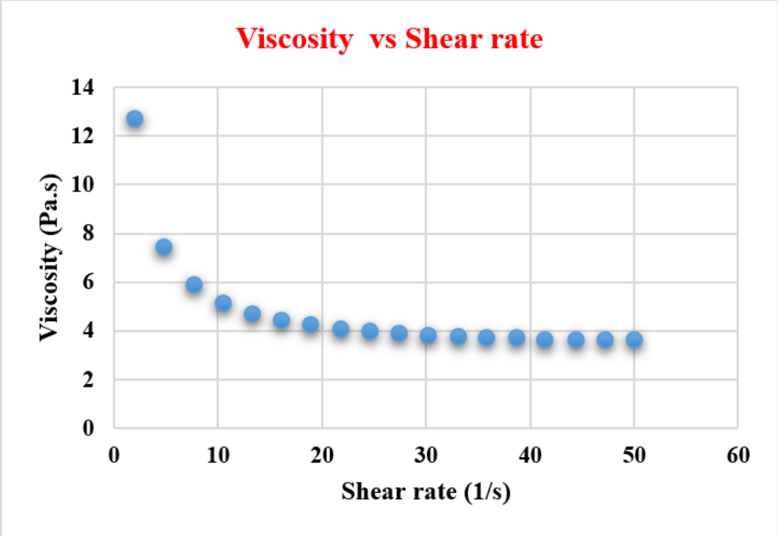

Fig. 1. Effect of shear rate on viscosity of chocolate

Milk compound chocolate indicated a shear thinning behaviour and the viscosity of chocolate was found to be 3.69 Pa.s. By using casson model, casson plastic viscosity and yield stress value of chocolate were determined as 2.28 Pa.s and 6.43 Pa, respectively. The viscosity of chocolate indicates how resistant it is to flow under the applied shear conditions during enrobing. A viscosity value of 3.69 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 6.43 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. The Casson plastic viscosity of chocolate, was found to be 2.28 Pa.s in this study. This value aligns well within the range reported by Toker et al. (2016) for casson plastic viscosity of compound milk chocolate (1.83–2.31 Pa.s). Chocolate will only start to flow when subjected to a shear stress greater than its yield stress (6.43 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 Base Cookies and Chocolate Enrobed Cookies

3.2.1 Physical properties of base cookies and enrobed cookies

The results of basic composition of the base cookies and enrobed cookies are shown in Table 2. The results of the 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 ($p< .05$).

Table 2. Basic composition of base cookies and enrobed cookies

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

^{a,b} *– means indicated with different letters in columns are significantly different (p<.05), n=5 ± standard deviation*

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 enrobed cookies.

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. 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. This is consistent with a study by Kumar et al. (2021) which found that chocolate coating improved the morphological properties of roasted flaked rice.

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

The total moisture content and water activity of base cookies and chocolate enrobed cookies increased significantly ($p<.05$), from 2.04 ± 0.08% to 2.82 ± 0.06% and from 0.32 ± 0.02 to 0.41 ± 0.01, respectively, as a result of the chocolate coating. According to Kumar et al. (2021), this increase in moisture content can be attributed to the properties of the coating ingredients. Hough et al. (2001) highlighted that water activity levels upto 0.6 are generally safe for cookies. Furthermore, Cauvain and Young (2006) recommended that freshly baked cookies should have a moisture content below 5%, while other standards, such as SLS 251:1991 and BIS 1974, suggested that moisture content during storage should remain under 6%. Hence, the results of this study are well within the recommended limits for safe storage.

3.2.2 Chemical analysis of base cookies and enrobed cookies

The proximate compositions of base 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 cookies before enrobing and varied from 19.78 ± 0.57 to 22.94 ± 0.78% ($p<.05$). 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 be 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 base cookies (487.17 ± 2.46 kcal). Increase in energy content is consistent with the elevated fat and protein content, which contribute more calories compared to carbohydrates. These results shows a statistically significant difference ($p<.05$) in the nutritional values of the cookies before and after enrobing. The findings from the study by Gupta and Mishra (2021), which showed improved nutritional values in chinese chestnuts after coated with dark chocolate, are consistent with the results of this study.

Table 3. Proximate compositions of base cookies and enrobed cookies

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

^{a,b}– means indicated with different letters in columns are significantly different ($p<.05$), n=5 ± standard deviation

Fig. 2. Base cookies and chocolate enrobed cookies

3.3 Chocolate Enrobing Ratio of Cookies

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 base 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). Base 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<.05). Furthermore, the b* value, representing the yellow-blue axis, also showed a significant decrease (P<.05) for enrobed cookies. 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 base cookies and enrobed cookies highlights a substantial visual transformation resulting from the enrobing process.

3.5 Sensory Analysis

Sensory evaluation results are given in Table 5. The sensory evaluation showed that enrobed cookies were significantly (p<.05) preferred over base cookies in various attributes. Enrobed cookies scored higher in appearance (8.80 ± 0.19) compared to base cookies (7.60 ± 0.22), highlighting the visual enhancement from chocolate coating. Colour ratings were also higher for enrobed cookies (8.60 ± 0.15) than base cookies (7.80 ± 0.45), reflecting an improved colour profile. Taste scores for enrobed cookies (8.80 ± 0.19) surpassed those of base cookies (7.60 ± 0.67) and flavour followed a similar trend with scores of 8.60 ± 0.18 for enrobed cookies and 7.80 ± 0.45 for base cookies, underscoring the positive sensory impact of enrobing. While there was no significant change (p=0.24) in crispiness between the enrobed cookies (8.40 ± 0.55) and base cookies (8.80 ± 0.15). A similar study by Kumar et al. (2021) found that the sensory attributes of the roasted flaked rice were

Table 4. Colour properties of base cookies and enrobed cookies

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

^{a,b} – means indicated with different letters in columns are significantly different (p<.05), n=5 ± standard deviation

Table 5. Sensory analysis of base cookies and enrobed cookies

Type of cookie	Appearance	Colour	Taste	Flavour	Crispiness	Overall acceptability
Base cookie	7.60 ± 0.22[b]	7.80 ± 0.45[b]	7.60 ± 0.67[b]	7.80 ± 0.45[b]	8.80 ± 0.15[a]	8.00 ± 0.45[b]
Enrobed cookie	8.80 ± 0.19[a]	8.60 ± 0.15[a]	8.80 ± 0.19[a]	8.60 ± 0.18[a]	8.40 ± 0.55[a]	8.80 ± 0.16[a]

[a,b]– means indicated with different letters in columns are significantly different ($p<.05$), n=5 ± standard deviation

significantly enhanced by chocolate coating. Furthermore, Enrobed cookies had higher overall acceptability (8.80 ± 0.16) compared to base cookies (8.00 ± 0.45). Overall, the chocolate enrobing process improved the appearance, colour, taste and flavour of the cookies. These findings are consistent with a study by Gounga et al. (2017), which also reported improved sensory properties due to coating.

4. CONCLUSION

This study evaluated the physicochemical properties of chocolate, base butter cookies and chocolate enrobed cookies. The flow behaviour of compound milk chocolate, used as an enrobing material, was also analysed 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, flavour and overall acceptability. The comparison between the cookies before and after enrobing showed a significant ($p<.05$) improvements in sensory and quality parameters. Addition of chocolate coating effectively enhanced the sensory and nutritional properties of the cookies. Studies have shown that chocolate coatings positively impact the nutritional composition of food products, providing manufacturers with opportunities to create diverse and decorative confections to meet consumer demand.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that generative AI technology (ChatGPT) have been used exclusively for paraphrasing during the writing or editing of the manuscript. All findings, interpretations and research remain entirely the work of the author(s).

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

Aeschlimann, J. M., & Beckett, S. T. (2000). International interlaboratory trials to determine the factors affecting the measurement of chocolate viscosity. *Journal of Texture Studies, 31*, 541–576.

Afoakwa, E. O., Paterson, A., & Fowler, M. (2007). Factors influencing rheological and textural qualities in chocolate – a review. *Trends in Food Science & Technology, 18*(6), 290–298.

Akdeniz, E., Yakışık, E., Rasouli Pirouzian, H., Akkın, S., Turan, B., Tipigil, E., Toker, O. S., & Ozcan, O. (2021). Carob powder as cocoa substitute in milk and dark compound chocolate formulation. *Journal of Food Science and Technology*, 1–9.

AOAC. (2005). *Official method of analysis* (18th ed.). Washington, DC: Association of Official Analytical Chemists.

Brown, M. (2009). Biscuits and bakery products. In G. Talbot (Ed.), *Science and technology of enrobed and filled chocolate, confectionery and bakery products* (pp. 152–162). Cambridge: Woodhead Publishing.

Bureau of Indian Standards. (n.d.). *BIS 1974. Specification for protein-rich biscuits* (IS 7487). New Delhi: Bureau of Indian Standards.

Cahyani, A., Kurniasari, J., Nafingah, R., Rahayoe, S., Harmayani, E., & Saputro, A. D. (2019). Determining Casson yield value, Casson viscosity, and thixotropy of molten chocolate using a viscometer. *IOP Conference Series: Earth and Environmental Science, 355*(1), 012041.

Cauvain, S., & Young, L. (2006). Ingredients and their influences. In S. Cauvain & L. Young (Eds.), *Baked Products: Science, Technology and Practice* (p. 72). Oxford: Blackwell Publishing.

Ertural, G. I., Gunes, R., Toker, O. S., Palabiyik, I., Konar, N., & Sagdic, O. (2023). Importance of rheological properties in enrobing efficiency of dark chocolate: Application in wafer products. *International Journal of Food Science and Technology, 58*(12), 5938–5946.

Gopalan, C., Sastri, B. V. R., & Balasubramanian, S. C. (1989). *Nutritive value of Indian foods*. Hyderabad: National Institute of Nutrition.

Gounga, M. E., Omar, K. A., Amadou, I., & Xu, S. Y. (2017). Chocolate coating effect on whey protein isolate-pullulan-coated freeze-dried chestnut. *American Journal of Food Science and Technology, 5*(3), 70–77.

Gupta, G., & Mishra, S. (2021). Nutritional and microbiological evaluation of dark chocolate coated Chinese chestnut. *Journal of Basic and Applied Research International, 27*(5), 29–37.

Haniyeh Rasouli-Pirouzian, S. H. Peighardoust, & S. Azadmard-Damirchi. (2017). Rheological properties of sugar-free milk chocolate: Comparative study and optimisation. *Czech Journal of Food Science, 35*(5), 440–448.

Hough, G., Buera, M. D. P., Chirife, J., & Moro, O. (2001). Sensory texture of commercial biscuits as a function of water activity. *Journal of Texture Studies, 32*(1), 57–74.

Hu, H., Wang, Y., Shen, M., Huang, Y., Li, C., Nie, S., Xie, M. (2022). Effects of baking factors and recipes on the quality of butter cookies and the formation of advanced glycation end products (AGEs) and 5-hydroxymethylfurfural (HMF). *Current Research in Food Science, 5*, 940–948.

Hussain, N., Agus, B. A. P., Rahim, S. N. F. A., & Halim, H. S. A. (2018). Comparison of quality characteristics between compound and pure milk chocolate. *MOJ Food Processing and Technology, 6*(2).

Konar, N., Toker, O. S., Oba, S., & Sagdic, O. (2016). Improving functionality of chocolate: A review on probiotic, prebiotic, and/or synbiotic characteristics. *Trends in Food Science & Technology, 49*, 35–44.

Kumar, S., Baniwal, P., Nayik, G. A., Prasad, K., Khan, K. A., Ghramh, H. A., Kumar, H., & Karabagias, I. K. (2021). Optimization and development of ready-to-eat chocolate-coated roasted flaked rice as instant breakfast food. *Foods, 10*(7), 1658.

Li, Y., Zhu, S., Feng, Y., Xu, F., Ma, J., & Zhong, F. (2014). Influence of alkalization treatment on the color quality and the total phenolic and anthocyanin contents in cocoa powder. *Food Science and Biotechnology, 23*(1), 59–63.

Naik, B., & Kumar, D. V. (2014). Cocoa butter and its alternatives: A review. *Journal of Bioresources Engineering and Technology, 1*(1), 7–17.

Sławińska, A., Jabłońska-Ryś, E., & Gustaw, W. (2024). Physico-chemical, sensory, and nutritional properties of shortbread cookies enriched with Agaricus bisporus and Pleurotus ostreatus powders. *Applied Sciences, 14*(5), 1938.

Sokol, N. V., Sanzharovskaya, N. S., Romanova, N. N., & Khrapko, O. P. (2021). Research of consumer properties of butter cookies composed of non-traditional raw materials. *IOP Conference Series: Earth and Environmental Science, 640*(6), 062016.

Sri Lanka Standards Institution. (1991). *SLS 251:1991. Specification for biscuits*. Sri Lanka Standards Institution.

Sundara, R., Manez, A., & Vieira, J. (2014). Enrobing in the confectionery industry. *New Food, 17*(1), 36–38.

Talbot, G. (2009). *Science and technology of enrobed and filled chocolate, confectionery and bakery products*. Cambridge: Woodhead Publishing.

Timbadiya, P. N., Bheda, S. B., Gajera, H. P., & Patel, S. V. (2017). Application of peanut butter to improve the nutritional quality of cookies. *Current Research in Nutrition and Food Science Journal, 5*(3), 398–405.

Toker, O. S., Sagdic, O., Sener, D., Konar, N., Zorlucan, T., & Daglioglu, O. (2016). The influence of particle size on some physicochemical, rheological and melting properties and volatile compound profile of compound chocolate and cocolin samples. *European Food Research and Technology, 242*, 1253–1266.

Wichchukit, S., McCarthy, M. J., & McCarthy, K. L. (2006). Flow behavior of milk chocolate melt and the application to coating flow. *Journal of Food Science, 70*(3), E165–E171.

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