



Value Addition in Dark Chocolate Through Fortification with Whey Protein Concentrate, Orange Peel and Pumpkin Seeds

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ABSTRACT

This study aimed to create a dark chocolate that not only delights the palate but also provides nutritional benefits by fortifying it with whey protein concentrate, candied dehydrated orange peels, and roasted pumpkin seeds. Dark chocolate (90 g) was enriched with 3 g whey protein, 4 g pumpkin seeds, and 3 g candied orange peel. The nutritional content, including protein, fiber, fat, ash, and carbohydrates, was analyzed, and sensory evaluation was conducted with panelists using a 9-point hedonic scale. Results showed notable increases in protein and fiber content, while taste, texture, aroma, and overall acceptability remained highly favorable. The study demonstrates that carefully combining functional ingredients can transform traditional chocolate into a nutritious, enjoyable, and health-promoting treat. This approach also supports sustainable use of food by-products, such as orange peel, adding environmental value to the product.

KEYWORDS

Functional chocolate, Whey protein, Pumpkin seeds, Candied dehydrated orange peel, Sensory evaluation

1. INTRODUCTION

Dark chocolate is widely recognized for its rich sensory properties and health benefits, particularly due to its high content of polyphenols and antioxidants (Afoakwa et al., 2007; Katz et al., 2011). In recent years, there has been a growing demand for functional foods that not only provide basic nutrition but also offer additional health benefits (Granato et al., 2010). Fortification of commonly consumed foods like chocolate presents an effective strategy to improve nutritional intake without altering consumer eating habits (Bigliardi & Galati, 2013). Incorporating nutrient-dense ingredients such as whey protein concentrate, pumpkin seeds, and citrus by-products like candied dehydrated orange peels can enhance both the nutritional and functional properties of chocolate. Whey protein concentrate is a high-quality protein source containing essential amino acids and exhibits excellent digestibility (Smithers, 2008), while pumpkin seeds are rich in healthy fats, minerals, and dietary fiber (Patel, 2013). Dehydrated orange peel, often considered a waste product, is a valuable source of fiber, antioxidants, and bioactive compounds (Gorinstein et al., 2001). Utilizing these ingredients not only improves the nutritional profile but also contributes to sustainable food processing through waste valorization (Ajila et al., 2010).

2. MATERIALS AND METHODS

2.1. Materials

The base ingredient for this study was dark chocolate, chosen for its rich flavor, high antioxidant content, and wide consumer acceptance (Afoakwa et al., 2007; Katz et al., 2011). To enhance its nutritional value, whey protein concentrate was added, providing high-quality protein and essential amino acids (Smithers, 2008). Roasted pumpkin seeds were incorporated for their healthy fats, minerals, fiber, and crunchy texture (Patel, 2013). To introduce natural sweetness, flavor, and additional antioxidants, candied dehydrated orange peels were included, also helping to reduce food waste by utilizing citrus by-products (Gorinstein et al., 2001; Ajila et al., 2010). All ingredients were sourced from reputable suppliers and stored under recommended conditions to maintain freshness and quality (Beckett, 2008). The chocolate, protein, seeds, and peels were carefully weighed for consistency in each trial. The combination aimed to create a product that is not only nutritious but also appealing in taste, aroma, and texture. These ingredients were selected based on their complementary nutritional profiles and their ability to harmonize in flavor.



Figure-1 - Raw materials for fortification of dark chocolate

2.2 Methods

Fresh orange peels were washed and sliced into thin strips. To reduce bitterness, the peels were blanched in hot water at 90°C for 5 minutes (Fellows, 2009). The blanched peels were then simmered in sugar syrup with a °Brix of 60 at 85°C for 30–40 minutes until they became translucent and adequately infused with syrup (Desrosier & Desrosier, 1977). After cooling, the peels were dehydrated in a hot-air oven at 60°C for 4–5 hours until the moisture content reached approximately 5–7%, ensuring improved shelf stability (Ranganna, 2010). For chocolate fortification, 3 g of candied orange peel was used per 90 g of dark chocolate.

Dark chocolate (90 g) was gently melted at 45°C using a double boiler to prevent scorching and maintain quality (Beckett, 2008). Whey protein concentrate (3 g) was gradually incorporated with continuous stirring to ensure uniform distribution (Smithers, 2008). Roasted pumpkin seeds (4 g) and candied orange peel (3 g) were then folded into the mixture. The chocolate was tempered by cooling to 28–30°C and reheating to 31–32°C to achieve desirable gloss and stable cocoa butter crystallization (Afoakwa et al., 2007). The tempered chocolate was poured into molds and allowed to solidify at 4°C for 30 minutes. The finished product was stored in airtight containers at room temperature until further analysis.

Table 1 - Formulation of fortified dark chocolate

INGREDIENTS	QUANTITY(Grams)
Dark chocolate compound	90
Orange peel	3
Pumpkin seeds	4
Whey protein concentrate	3

3. PHYSIO-CHEMICAL ANALYSIS

The physicochemical characteristics of the fortified dark chocolate were evaluated to determine its quality, stability, and nutritional contribution. Moisture content was measured using the oven-drying method at 105°C until constant weight, which helps assess shelf life and microbial stability (AOAC, 2016). Ash content, indicating total mineral content, was determined by incineration of the sample in a muffle furnace at 550°C (Ranganna, 2010). Fat content was analyzed using Soxhlet extraction with petroleum ether, providing information on the lipid fraction, which influences texture, mouthfeel, and caloric value (AOAC, 2016). Protein content was assessed using the Kjeldahl method, measuring total nitrogen and converting it to protein, with whey protein contributing significantly to the overall content (Nielsen, 2017). Crude fiber was estimated through sequential acid and alkali digestion to determine the dietary fiber provided by the orange peel and pumpkin seeds (AOAC, 2016). Carbohydrate content was calculated by difference, subtracting the sum of moisture, protein, fat, and ash from 100 (Ranganna, 2010). The equipment used for physicochemical analysis is shown in Figure 2 below.



Figure 2 Equipment used for physicochemical analysis

3.1 Determination of Moisture content by loss on drying method

The moisture content of the chocolate sample was determined using the Loss on Drying (LOD) method. A representative sample (3 g) was placed in a pre-weighed Petri dish and dried in a hot-air oven at 105°C until constant weight was obtained. The sample was then cooled in a desiccator and weighed. The loss in weight corresponds to the moisture content (AOAC, 2016).

$$\text{Moisture (\%)} = \frac{\text{Weight of wet sample} - \text{Weight of dry sample}}{\text{Weight of wet sample}} \times 100$$

Where:

W = Weight of empty Petri dish

W1 = Weight of Petri dish with sample after drying to constant weight

W2 = Weight of Petri dish with sample after drying to constant weight

3.2 Determination of Ash content

Ash content measures the total mineral matter present in chocolate and is an important indicator of its nutritional value and quality. The method involves weighing a known amount of chocolate in a clean, dry crucible and incinerating it in a muffle furnace at approximately 550°C until all organic matter is completely burned, leaving only inorganic residue (ash). After cooling the crucible in a desiccator, the remaining ash is weighed. (Ranganna, 2010). The percentage of ash is calculated using the formula:

$$\text{Ash (\%)} = \frac{\text{Weight of crucible + ash (W3)} - \text{Weight of empty crucible (W1)}}{\text{Weight of crucible + sample (W2)} - \text{Weight of empty crucible (W1)}} \times 100$$

Where:

W1 = weight of empty crucible

W2 = weight of crucible + chocolate sample

W3 = weight of crucible + ash

3.3 Determination of crude fiber content

Crude fiber represents the indigestible portion of the chocolate derived from plant-based ingredients, such as candied orange peel and pumpkin seeds, and provides dietary fiber. The method involves sequential acid and alkali digestion of a known weight of the chocolate sample to remove soluble substances, followed by filtration and drying of the residue. The dried residue is then weighed, and optionally incinerated to remove ash, leaving only the crude fiber content. (AOAC, 2016). The percentage of crude fiber is calculated using the formula:

$$\text{Crude Fiber (\%)} = \frac{\text{Weight of residue after drying (W2)} - \text{Weight of ash (W3)}}{\text{Weight of sample (W1)}} \times 100$$

Where:

W1 = weight of the sample

W2 = weight of dried residue

W3 = weight of ash after incineration

3.4 Determination of protein content

Protein content in chocolate is determined by the Kjeldahl method, which measures the total nitrogen and converts it to protein using a conversion factor. A known weight of chocolate is digested with concentrated sulfuric acid (H₂SO₄) in the presence of a catalyst, converting organic nitrogen into ammonium sulfate. After digestion, the mixture is neutralized with sodium hydroxide (NaOH), releasing ammonia (NH₃), which is distilled into a known volume of standard acid solution. The absorbed ammonia is then titrated with a standard base to determine the amount of nitrogen. (Nielsen, 2017). The percentage of protein is calculated using the formula:

$$\text{Protein (\%)} = \text{Nitrogen (\%)} \times \text{Conversion factor (6.25 for chocolate)}$$

$$\text{Where Nitrogen (\%)} = \frac{(V_{\text{sample}} - V_{\text{blank}}) \times N_{\text{HCl}} \times 14.01}{\text{Weight of sample (g)}} \times 100$$

3.5 Determination of fat content

Fat content in chocolate is determined by the Soxhlet extraction method, which quantifies total lipids by extracting them with a suitable organic solvent, typically petroleum ether. 3 grams chocolate is placed in a thimble inside the Soxhlet apparatus. The solvent is heated to reflux, and fat is repeatedly washed over the sample for several hours, dissolving all extractable lipids. After extraction, the solvent is evaporated, and the remaining fat is dried to constant weight in a pre-weighed flask. (AOAC, 2016). The percentage of fat is calculated using the formula:

$$\text{Fat (\%)} = \frac{\text{Weight of extracted fat}}{\text{Weight of sample}} \times 100$$

Where the weight of extracted fat = weight of flask + fat – weight of empty flask

3.6 Determination of Vitamin C

Vitamin C content in orange peel is determined using a redox titration method with 2,6-dichlorophenolindophenol (DCPIP) as the titrant. 2grams of sample is homogenized in a small amount of distilled water to extract the vitamin, and the solution is filtered. The filtrate is titrated with standardized DCPIP solution until a persistent pink color appears, indicating the endpoint. The amount of DCPIP used is directly proportional to the Vitamin C content. (Ranganna, 2010).The Vitamin C concentration is calculated using the formula:

$$\text{Vitamin C (mg/100g)} = \frac{V \times N \times 176.12 \times 100}{W}$$

Where:

V = volume of DCPIP used (mL)

N = normality of DCPIP

176.12 = molecular weight of ascorbic acid (mg/mmol)

W = weight of chocolate sample (g)

3.7 Determination of Carbohydrates

Carbohydrates are calculated indirectly by subtracting the percentages of other proximate components (moisture, protein, fat, ash, and fiber) from 100% (Ranganna, 2010).

$$\text{Carbohydrates (\%)} = 100 - [\text{Moisture (\%)} + \text{Protein (\%)} + \text{Fat (\%)} + \text{Ash (\%)} + \text{Crude fiber}]$$

Where:

Moisture (%) = determined by Loss on Drying method

Protein (%) = determined by Kjeldahl method (Nitrogen \times 6.25)

Fat (%) = determined by Soxhlet extraction

Ash (%) = determined by incineration in a muffle furnace

Crude Fiber (%) = determined by acid-alkali digestion

4. RESULTS

4.1 Nutritional and physicochemical Analysis

The Nutritional and physicochemical parameters of the fortified dark chocolate were measured, including moisture, ash, fat, protein, fiber, and carbohydrate content. (Smithers, 2008). Nutritional and Physicochemical Parameters of Fortified Dark Chocolate are given below table-2

Table-2 Nutritional and Physicochemical Parameters of Fortified Dark Chocolate

Parameter	Amount (g/100g or mg/100g)
Carbohydrates	50
Dietary Fiber	0.89
Protein	7.23
Fat	36.1
Moisture	1.5
Ash	2.5

This below figure represents a graphical representation of the nutritional composition of fortified dark chocolate using a bar chart. Different nutrients such as carbohydrates, fat, protein. (Ranganna, 2010).

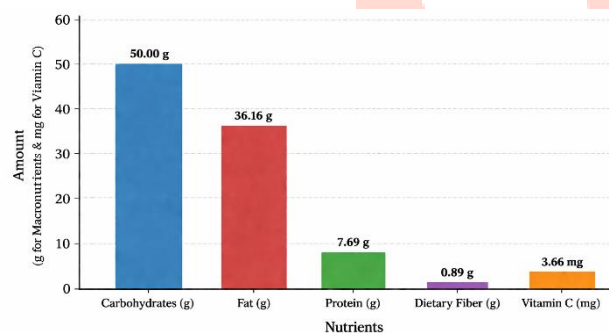


Figure 3: Represents the Nutritional Composition of Fortified Dark Chocolate

4.2 SENSORY EVALUATION

The sensory attributes of the fortified dark chocolate were assessed to determine consumer acceptability and the impact of added functional ingredients. Panelists were asked to evaluate the chocolate on key attributes including appearance, color, texture (mouthfeel), aroma, taste (bitterness, sweetness, and overall flavor), and overall acceptability. A 9-point hedonic scale was employed, where 9 indicated "like extremely" and 1 indicated "dislike extremely." (Stone & Sidel, 2004). Data from the sensory evaluation were analyzed statistically to compare different formulations or trials, helping identify the optimal combination of whey protein concentrate, candied dehydrated orange peel, and roasted pumpkin seeds that provides the best balance between nutritional enhancement and sensory appeal (Granato et al., 2010).

PARAMETER	PANEL MEMBER-1	PANEL MEMBER-2
Appearance	9	9
Texture	8	8
Colour	9	9
Taste	9	9
Aroma	9	9
Overall acceptability	9	9

Table 3: The sensory evaluation of fortified chocolate by two panel members

5.DISCUSSION

The fortification of dark chocolate with whey protein concentrate, candied dehydrated orange peel, and roasted pumpkin seeds significantly enhanced its nutritional and functional properties without compromising sensory quality. The addition of whey protein concentrate increased the protein content, making the chocolate a potential functional food for individuals seeking higher protein intake (Smithers, 2008). Candied dehydrated orange peel contributed dietary fiber along with a natural citrus flavor, improving palatability and providing antioxidant benefits (Gorinstein et al., 2001; Ajila et al., 2010). The incorporation of roasted pumpkin seeds enriched the chocolate with essential minerals, healthy fats, and a subtle nutty taste, thereby enhancing overall acceptability (Patel, 2013). Physicochemical analysis showed slight increases in moisture, ash, protein, fat, and fiber, while carbohydrate content marginally decreased due to the replacement of chocolate mass with nutrient-dense ingredients (Ranganna, 2010). Sensory evaluation indicated that the fortified chocolate, particularly Trial 3, was highly acceptable in terms of appearance, color, texture, taste, and overall acceptability, suggesting that the optimized formulation successfully balanced nutritional enhancement with sensory appeal (Stone & Sidel, 2004). These findings demonstrate that the developed fortified dark chocolate can serve as a functional confectionery product, combining indulgence with health benefits. Moreover, the study highlights a sustainable approach to value addition through the utilization of citrus by-products such as orange peel, contributing to waste reduction in the food industry (Ajila et al., 2010).

6.CONCLUSION

This study successfully developed a functional dark chocolate enriched with whey protein concentrate, roasted pumpkin seeds, and candied dehydrated orange peels, demonstrating that nutritional enhancement can be achieved without compromising sensory qualities. The fortified chocolate showed notable increases in protein and dietary fiber, while maintaining excellent taste, texture, aroma, and overall acceptability, making it suitable for health-conscious consumers seeking indulgent yet nutritious snacks. Incorporating candied orange peel not only adds antioxidants and dietary fiber but also promotes sustainable food practices by utilizing a citrus by-product that would otherwise be wasted. The combination of ingredients provides a balanced, nutrient-rich product that supports cardiovascular health, digestion, and overall well-being. Overall, this research demonstrates the potential to create functional chocolates that are both enjoyable and health-promoting, offering a practical framework for future development of innovative, nutritionally enhanced confectionery products.

7.REFERENCES

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