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Formulation and chemical characteristics test on high protein gummy candy products with whey protein concentrate substitution

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ABSTRAK

Latar Belakang: *Makanan tambahan dibutuhkan untuk melengkapi kebutuhan gizi balita, namun camilan komersial sering kali tinggi gula dan natrium tetapi rendah protein.Pengembangan pangan fungsional seperti permen gummy tinggi protein dapat membantu memenuhi kebutuhan protein balita serta mengatasi masalah gizi di Indonesia.*

Tujuan: *Merumuskan, menganalisis parameter organoleptik, dan melakukan analisis proksimat pada berbagai formulasi permen gummy Whey Protein Konsentrat (WPC).*

Metode: *Penelitian kuantitatif dengan desain eksperimental.Terdapat 4 sampel formulasi yaitu Formulasi 0 (F0) Tanpa WPC, Formulasi 1 (F1) 100 gram WPC, Formulasi 2 (F2) 150 gram WPC, Formulasi 3 (F3) 200 gram WPC. Analisis data menggunakan uji statistik non parametrik berbasis nilai. Analisis Duncan digunakan untuk analisis perbedaan kandungan gizi makro antar formulasi.*

Hasil: *Hasil uji organoleptik dengan komponen warna, aroma, rasa dan tekstur pada permen gummy WPC menunjukkan tidak terdapat perbedaan signifikan pada semua formulasi F0, F1, F2 dan F3. Namun terdapat perbedaan signifikan pada aspek tekstur antar formulasi (p-value < 0,05). Hasil uji proksimat menunjukkan rata -rata skor uji proksimat pada masing-masing formulasi dengan kandungan protein didapatkan hasil pada F0 sebesar 9,66%, F1 21,63%, F2 26,45% dan F3 29,10%. Formulasi terbaik yang terpilih yaitu F3, dengan kandungan gizi berupa energi total 164.70 kkal, energi dari lemak 17,23 kkal, kadar air 60,18%, kadar abu 1,03%, protein 29,10%, lemak 1,91% dan karbohidrat 7,76%.*

Kesimpulan: *Tekstur permen gummy berbeda signifikan di setiap formulasi (F0 sampai F3), sementara warna, aroma, dan rasanya tidak ada perbedaan; formulasi F3 paling optimal untuk permen gummy bernutrisi, dengan kandungan protein tertinggi (29,10%) dan energi total (164,70 kkal).*

KATA KUNCI: *permen gummy; protein; whey protein konsentrat*

ABSTRACT

Background: *Complementary foods are needed to meet toddlers' nutritional requirements; however, commercial snacks are often high in sugar and sodium but low in protein. The development of functional foods such as high-protein gummy candies may help fulfill toddlers' protein needs and address nutritional problems in Indonesia.*

Objectives: *To formulate whey protein concentrate (WPC) gummy candies, evaluate organoleptic parameters, and conduct proximate analysis across different formulations.*

Methods: *This quantitative study employed an experimental design. Four formulations were prepared: Formulation 0 (F0) without WPC, Formulation 1 (F1) with 100 g WPC, Formulation 2 (F2) with 150 g WPC, and Formulation 3 (F3) with 200 g WPC. Data were analyzed using non-parametric rank-based statistical tests. Duncan's test was used to assess differences in macronutrient content among formulations.*

Results: *Organoleptic evaluation of color, aroma, taste, and texture of WPC gummy candies showed no significant differences among F0, F1, F2, and F3. However, a significant difference was found in texture between formulations (p-value < 0.05). Proximate analysis showed that the mean protein content was 9.66% in F0, 21.63% in F1, 26.45% in F2, and 29.10% in F3. The best formulation was F3, with a nutritional composition of total energy 164.70 kcal, energy from fat 17.23 kcal, moisture content 60.18%, ash content 1.03%, protein 29.10%, fat 1.91%, and carbohydrates 7.76%.*

Conclusion: *Gummy candy texture differed significantly across formulations (F0–F3), while no differences were observed in color, aroma, or taste. Formulation F3 was the most optimal for producing a nutritious gummy candy, with the highest protein content (29.10%) and total energy (164.70 kcal).*

KEYWORD: *gummy candy; protein; whey protein concentrate*

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INTRODUCTION

Adequate nutrition in toddlers is essential to support growth and immunity. However, in Indonesia, commercial snacks, which are often high in sugar and sodium but low in protein, contribute to chronic malnutrition, early obesity, and dental caries (1,2). SUSENAS data (2022) shows that the average protein intake is 64.54 g/day, exceeding the recommended 57 g. However, animal protein is still low (7.40 g meat, 5.15 g eggs/milk, 15.72 g fish), while rice dominates as a plant-based source (31.34 g), indicating an imbalance in protein quality and food sources (3). Protein builds tissue, supports DNA/RNA synthesis, and boosts immunity (4), while carbohydrates provide energy for metabolism and brain activity (5,6).

Whey protein concentrate (WPC), which comes from whey milk by-products, contains up to 80% protein and is rich in essential amino acids, particularly the branched-chain amino acids (BCAAs). Per 100 grams of protein, WPC provides approximately 10.4 g of leucine that stimulate muscle protein synthesis via mTOR, and its fast digestion makes it suitable for toddlers (8), 6.25 g of isoleucine, and 5.93 g of valine, making it one of the richest dietary sources of BCAAs. The high leucine content plays a critical role in stimulating muscle protein synthesis through the mTOR pathway and supports tissue repair processes. In addition to its substantial BCAA content, WPC is also rich in other essential amino acids that contribute to its high biological value. According (7), WPC contains 8.92 g of lysine, 7.14 g of threonine, 3.16 g of phenylalanine, and 2.14 g of methionine per 100 g of protein. This complete amino acid profile strengthens the function of WPC as a nutrient-dense food ingredient capable of supporting growth, tissue maintenance, and overall nutritional status across different age groups.

However, the use of WPC in appealing snack foods such as chewy candies is still limited, especially in developing countries (9), this limitation occurs because conventional jelly candies are high in sugar but low in protein. Therefore, innovation is needed by replacing refined sugar with stevia as a natural sweetener to prevent tooth decay and improve nutritional value (10). Previous research by (11) used pumpkin as a source of plant-based protein with cane sugar, which is less optimal than animal-based WPC, indicating a gap in WPC-stevia-based gummy formulations to optimize protein intake for toddlers. Therefore, this study aims to to obtain the best high-protein gummy candy formulation with varying levels of WPC substitution.

MATERIALS AND METHODS

This study is an experimental study using a completely randomized design (CRD) to test the effect of adding whey protein concentrate (WPC) on the sensory and chemical characteristics of high-protein gummy candies. Four formulations of chewy candy were prepared: F0 (control, without WPC), F1 (100 g WPC), F2 (150 g WPC), and F3 (200 g WPC), each with three replicates. Ethical approval was obtained from the Faculty of Public Health, Sriwijaya University (Number: 376/UN9.FKM/TU.KKE/2024, valid from November 8, 2024, to November 8, 2025).

The research was conducted in several locations according to the type of analysis performed. Product processing was carried out at the researcher's residence in Timbangan, Indralaya. The organoleptic tests were conducted at the Culinary and Dietetics Laboratory of the Faculty of Public Health, University of Sriwijaya. The Proximate Analysis Test was conducted at PT. Saraswanti Indo Genetech (SIG) in Bogor, which is accredited by KAN (National Accreditation Committee) with accreditation certificate number NO. LP-184-IDN - SNI ISO/IEC 17025:2017, as an accredited testing and calibration laboratory.

Production of Whey Protein Concentrate Gummy Candy

Gummy candies are made using the following main ingredients: gelatin (25 g, Hakiki brand), stevia extract (0.8 ml, Vitmaker brand), drinking water (500 ml), and vanilla flavoring (0.5 g, L'arome brand). WPC (80% protein content), sourced from PT. Leprino Foods is added at varying levels. The procedure involved: (1) mixing WPC, stevia, and water in one bowl; (2) dissolving gelatin in water in a second bowl; (3) heating the gelatin mixture to 60°C; (4) combining the mixtures, pouring into silicone molds, and cooling in the refrigerator for 2-4 hours.

Organoleptic Test

Thirty semi-trained panelists (Nutrition students, sixth semester or higher) evaluated random samples using a 5-point hedonic scale (1 = strongly dislike; 5 = strongly like), who were selected based on Inclusion Criteria such as had no sensory impairment (smell, taste, vision), no food allergies, and prior experience in sensory testing. Exclusion criteria included students outside the program, those who were acutely ill, or those who did not meet the experience requirements. The organoleptic test used a 5-point hedonic scale (1: strongly dislike; 5: strongly like) by panelists on random samples.

Proximate Analysis

Proximate analysis of selected formulations was performed at the accredited laboratory of PT. Saraswanti Indo Genetech (SIG), Bogor, Indonesia, following AOAC methods: moisture and ash content by gravimetric drying/ignition (AOAC 925.10, 923.03), protein by Kjeldahl (AOAC 2001.11), fat by Soxhlet extraction (AOAC 920.39), and carbohydrates by the difference method.

RESULTS AND DISCUSSIONS

Organoleptic Test of Color Components

Preference levels for the color, aroma, texture, and taste of Whey Protein Concentrate Gummy Candy presented in **Table 1**.

Table 1. Preference levels for the color, aroma, texture, and taste of whey protein concentrate gummy candy

Parameter	Mean Value of the Hedonic Test for Gummy Candy Samples				*p-value*
	F0	F1	F2	F3	
Color	3.93 ± 0.87[a]	3.60 ± 0.67[a]	3.70 ± 0.60[a]	3.63 ± 0.56[a]	0
Aroma	4.03 ± 0.76[a]	4.00 ± 0.79[a]	4.07 ± 0.74[a]	3.73 ± 0.52[a]	
Texture	3.90 ± 0.66[a]	3.10 ± 0.84[b]	2.93 ± 0.83[b]	2.90 ± 0.81[b]	
Taste	3.57 ± 0.73[a]	3.13 ± 0.73[a]	3.37 ± 0.96[a]	3.17 ± 0.83[a]	

Explanation: 5 = Really like, 4 = Like, 3 = Neutral, 2 = Don't like, 1 = Really dislike
Explanation: a, b, c = similar letter notation means there is no significant difference at the Mann-Whitney test level of 5%.

The organoleptic evaluation by 30 panelists indicated that the control formulation (F0) had the highest color preference score of 3.93, while the addition of whey protein concentrate (WPC) slightly reduced preference due to pigment changes in the product. Normality analysis showed a significance value of 0.00 ($p<0.05$), confirming that the data were not normally distributed. Data were analyzed using the Kruskal–Wallis test (α=0.05), and the results indicated no significant differences in color preference among treatments. The results yielded a significance value of 0.450 (>0.05), confirming that there were no significant differences between treatments (F0-F3) in the color variable of WPC gummy candy **Table 1**.

WPC has a brownish-yellow color (15). This yellow color indicates an increase in the fat content of the milk (12) and is caused by beta-carotene from cattle feed (13), so that higher WPC substitution increases the color intensity of the gummy (14). Although the lowest substitution showed an effect on color, there were no significant differences between formulations, presumably because limited heating (60°C, short time) prevented color intensification, but low heating avoids the Maillard reaction, which is a chemical reaction between proteins/amino acids and sugars that produces a brownish color change (16) so that the browning index remains low and the color change is not noticeable. These findings emphasize the importance of processing conditions for maintaining sensory aesthetics in protein fortification, contributing to the optimization of functional gummy formulations without compromising visual appeal. These results indicate that the addition of WPC does not significantly affect the color of the gummy.

Organoleptic Test of Aroma Components

The organoleptic test by 30 panelists resulted in aroma preference scores for WPC gummy candy ranging from 3.73 (F3, normal category; lowest) to 4.07 (F2, like category; highest), with normality testing showing a significance value of 0.00 (<0.05) indicating a non-normal distribution, thus proceeding to the Kruskal-Wallis test (α=0.05) with resulting in a p-value of 0.270 (>0.05), confirming no significant differences between treatments (F0-F3) **Table 1**.

Aroma, as a subjective indicator, depends on sensitivity of smell and can affect appetite (17). This refers to the composition of odorous compounds that interact with taste and smell receptors, producing different combined perceptions from individual components (18) The aroma of the gummy was dominated by the milky notes of WPC, with F2 being the most preferred, and this non-significant difference is in line with Marques et al. (2016) (19) who found that the addition of WPC to sugar-free cookies did not significantly affect the aroma, with panelist acceptance >80%. Heating at 60°C causes low denaturation of whey proteins (β-lactoglobulin, α-lactalbumin, lactoferrin), resulting in few volatile compounds and minimal changes in milk aroma compared to higher temperatures (20).

The addition of vanilla flavoring enhances the aroma, while optimal WPC substitution increases milk intensity without excessive interference. These findings highlight aroma stability in whey fortification during low-heat processing, contributing to the development of functional gummies that maintain sensory appeal for consumers sensitive to odor changes, while emphasizing the role of flavorings as volatile modulators.

Organoleptic Test of Texture Components

The organoleptic test by 30 panelists resulted in WPC gummy candy texture preference scores ranging from 2.9 (F3, normal category; lowest) to 3.9 (F0, like category; highest), with normality testing showing a significance value of 0.00 (<0.05) indicating a non-normal distribution, therefore, the Kruskal–Wallis test (α=0.05) was applied, confirming a significant difference between treatments (F0–F3). The Mann-Whitney follow-up test revealed significant differences (p<0.05) between F0 and F1, F2, and F3, but no significant differences (p>0.05) between F1-F2, F1-F3, and F2-F3 **Table 1**.

The characteristic chewy texture of gummy candies, which is the main attraction for consumers, results from the interaction of gelatin (as a gelling agent) with sugar, syrup, and water; when heated, gelatin molecules form a network that binds water to create an elastic and dense structure (21). WPC substitution produced a chewy but grainy texture with higher density, due to increased protein and decreased free water through WPC's water-binding ability (22). This bonding reduces water mobility and increases stability through hydrogen and electrostatic interactions (23). These changes are due to the high-protein functional properties of WPC, including gel formation, thickening, and interaction with carbohydrates (24). These properties are influenced by molecular weight, amino acid profile, charge, and protein molecular structure (25), resulting in solid texture modification and a grainy sensation from complex interactions. Perhaps due to increased tightness and a slightly gritty sensation in the mouth. These findings align with Zhu et al. (2023) (26) who reported the thickening effects of whey protein similar to hydrocolloids and starch. Overall, the results highlight the fortification of WPC in maintaining gummy elasticity, contributing to hybrid formulation strategies for optimal functional snacks for consumers with elastic texture preferences, while emphasizing the need for further research on protein-gelatin interactions to reduce gritty texture.

Organoleptic Test of Taste Components

The organoleptic test by 30 panelists resulted in taste preference scores for WPC gummy candy ranging from 3.13 (F1, normal category; lowest) to 3.57 (F0, normal category; highest), with F0 obtaining the highest score (3.57, normal/somewhat liked). The results of the data normality test showed a significance value of (0.00), which was lower than the specified significance level (0.05), indicating that the data distribution did not meet the normal requirements. Therefore, the Kruskal-Wallis test was applied with a significance level of (0.05). The Kruskal–Wallis analysis did not show significant differences between formulations (p=0.152 > 0.05) was found, indicating no significant difference in treatment (F0, F1, F2, and F3) on the flavor attributes of WPC chewy candy **Table 1**. Higher WPC substitution reduced taste preference, in line with Marques et al. (2016) (19) who reported that a high proportion of WPC (54.1 g/100 g) reduced taste acceptance in cookies. The product flavor was dominated by the sweetness of stevia extract with a distinctive WPC milk flavor, but a slight gritty sensation was perceived during chewing due to increased solids and decreased free water (23). WPC fortification significantly reduced sweetness intensity compared to the control, due to the interaction of protein with sugar and flavorings that masked the perception of sweetness (27).

Overall, WPC enhances nutritional value but reduces flavor acceptance at high concentrations, resulting in a bland sensation; optimal formulations require the addition of sweeteners or flavorings to counteract these negative effects (28). These findings emphasize the need for balanced protein fortification in the development of functional gummies, contributing to sensory strategies that maintain sweetness for broader consumer acceptance while supporting the application of stevia as a natural sweetener in low-sugar products. Adding moderate amounts of WPC provides the best balance between nutritional value and palatability.

Proximate Analysis Test

Chemical Analysis Results of Gummy Candy presented in **Table 2**.

Table 2. Chemical analysis results of gummy candy

Parameter	Unit	Chemical Analysis Results of Gummy Candy			
		F0	F1	F2	F3
Total Energy	Kcal/100 g	44.91	90.81	162.13	164.7
Energy from Fat	Kcal/100 g	4.84	2.89	14.35	17.23
Moisture Content	%	89.29	77.09	60.88	60.18
Ash Content	%	0.1	0.63	0.91	1.03
Protein	%	9.66	21.63	26.45	29.1
Total Fat	%	0.54	0.32	1.57	1.91
Carbohydrates	%	0.4	0.31	10.1	7.76

Source: Secondary Data Researcher, 2025

The increase in total energy in the product was due to the high protein content of WPC **Table 2**, including essential amino acids and bioactive peptides, which support energy metabolism (29). Analysis of the formulation composition shows that whey protein concentrate (WPC) contributes 4 kcal/g, so that the increase in protein substitution in treatments F1–F3 (compared to F0) directly increases the total calories in the gummy candy, in accordance with the adjusted proportions of ingredients in the recipe. This finding is in line with Lestari and Dewi (2017) (30) who reported that the addition of high-protein ingredients increases the total energy of candy.

Water content decreased in F3 because WPC binds water effectively, forming a stable structure that limits free moisture and improves texture stability (31). Its interaction with gelatin enhances water retention within the gummy matrix (32). Heating removes part of the water, while cooling traps the remaining moisture (33,34). These results show that WPC helps extend the shelf life of functional gummies by reducing water migration.

Ash content, as a residue of inorganic minerals resistant to combustion, is low in F0 due to the minimal minerals in the base material (32); the increase in F3 is due to natural minerals in WPC such as calcium (0.5-1.5%), phosphorus (0.4-1.0%), from the milk whey isolation process (35,36). The addition of WPC increases the ash content through the contribution of total minerals **Table 2.** Overall, WPC fortification enriches the mineral profile of gummies, supporting functional nutrition claims.

This protein increase is expected because WPC contains 80% high-quality protein on a dry weight basis, rich in essential and bioavailable amino acids, ideal for nutritional fortification (37). Bioactive components such as β-lactoglobulin, α-lactalbumin, and immunoglobulin support immunity and tissue growth (38). WPC substitution significantly enriches the nutritional value of gummies, with broad applications in functional food products.

The percentage of fat content increases with WPC substitution. WPC, a cheese by-product processed through microfiltration and ultrafiltration, contains low fat (≤4%, often <1%) to support low-fat applications (39); the natural fat in WPC is about 3%. Higher WPC substitution contributes to increased fat in F3 due to higher WPC substitution, although it is still minimal compared to conventional products.

The use of stevia as a sweetener in WPC maintains a low total carbohydrate content (~5% lactose) compared to sugar cane-based chewing gum (40). These findings are consistent with (41) which reports that sugar-free gum has relatively low energy and carbohydrate content. The differences between formulations are due to decreases in water content (F0/F1 high water content, low carbohydrates; F2 sharp decrease in water, relative increase in carbohydrates; F3 stable with possible protein-sugar bonding through Maillard reactions, reducing free carbohydrates). These results support the development of low-carbohydrate gummies for a healthy diet.

CONCLUSION AND RECOMMENDATIONS

Organoleptic test results demonstrate that WPC fortification influences preference levels for texture across formulations F0, F1, F2, and F3. This fortification also affects proximate analysis outcomes, particularly protein content, with F3 (200 g WPC) showing the highest protein level at 29.10%. Key findings reveal that higher WPC levels primarily impact texture and protein content. For further research, explore incorporating additional gelling agents such as gelatin and carrageenan to improve gummy candy texture. Technically, extend heating duration and intensify heat during the cooking process to effectively evaporate excess water. These findings suggest that WPC-fortified gummies have potential as a high-protein, healthy snack option.

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