



Formulation of Pumpkin Seed (*Cucurbita moschata*) Powder Multivitamin Gummies with Varying Concentrations of Added Sucrose and Stevia Sweeteners

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Article Info

Article history:

Received Jul 20, 2026

Revised Aug 10, 2026

Accepted Sep 25, 2026

OnlineFirst Sep 30, 2026

Keywords:

Applied Science

Cucurbita moschata

Multivitamin Gummy

Sucrose

Stevia

Yellow Pumpkin Seeds

ABSTRACT

Purpose of the study: This study aimed to formulate yellow pumpkin seed (*Cucurbita moschata*) powder-based multivitamin gummies and evaluate how varying sucrose and stevia concentrations affected physical characteristics, microbiological quality, zinc concentration, and consumer acceptability.

Methodology: This laboratory experimental study used nine formulations: control (F0), sucrose (F1–F4; 30–45%), and stevia (F1–F4; 0.30–0.45%). Evaluations included organoleptic characteristics, weight uniformity, cutting point, homogeneity, stability, microbiological quality, zinc content by AAS, and hedonic acceptability. We analyzed cutting point data using One-Way ANOVA, while we analyzed hedonic results descriptively based on mean scores from 20 respondents.

Main Findings: Both sucrose and stevia groups showed significant differences in cut-off point values ($p = 0.002$ and $p = 0.001$, respectively). F3 showed cut-off point values of 122 ± 6 g for sucrose and 121.67 ± 5.77 g for stevia. Microbiological testing of F3 showed negative *Salmonella* sp. results, while ALT and AKK met the requirements. Zinc concentrations were 2.9761 and 2.168 mg/L, respectively. F3 obtained the highest hedonic mean scores, 4.63 for sucrose and 4.45 for stevia.

Novelty/Originality of this study: This study provides a formulation approach using yellow pumpkin seed powder rather than an extract and compares sucrose and stevia systems across concentrations. The study identified F3 as a promising formulation based on its characteristics and descriptive acceptability. The study also clarifies that microbiological and zinc results were obtained only from tested F3 samples, supporting further formulation optimization and broader quality evaluation.

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1. INTRODUCTION

The problem of meeting vitamin and mineral needs is still widely found in the community, especially due to unbalanced diets, high consumption of instant food, and low public awareness of the importance of balanced nutrition. This condition causes micronutrient intake to not be met optimally, so many people are not

Journal homepage: <http://cahaya-ic.com/index.php/ISEJ>

able to meet the body's nutritional needs only from daily food. Therefore, additional efforts are needed to help meet the adequacy of vitamins and minerals to maintain a healthy body [1]-[4]

Vitamins and minerals play an important role in maintaining various physiological functions of the body, including metabolism, growth, and the immune system. Vitamin and mineral deficiencies can cause the body to not function optimally and increase the risk of health problems. One of the essential minerals that has an important role in the immune system is zinc. Zinc functions in enzyme activity, DNA and protein synthesis, energy metabolism, and cell growth and differentiation processes. In addition, zinc also plays an important role in optimizing the function of the immune system so that it contributes to maintaining immunity [5]-[9].

This condition encourages the increase in the consumption of multivitamin products as an alternative to help meet the needs of vitamins and minerals. However, conventional forms of multivitamin preparations such as tablets and capsules still have limitations for certain groups, as they are less practical and lower consumption adherence [10]-[12]. To improve consumption compliance, multivitamin innovations are needed in the form of preparations that are easier to consume. Gummy preparations have a chewy texture, sweet taste, and pleasant consumption sensation, making them preferable to tablets or capsules. In addition, gummy is widely developed as a medium for delivering vitamins and minerals because it is able to increase acceptance and compliance with consumption [13]-[16].

Yellow pumpkin seeds (*Cucurbita moschata*) contains a variety of essential nutrients such as the minerals zinc, magnesium, phosphorus, protein, vitamin E, vitamin B complex, as well as essential fatty acids that play a role in supporting the body's metabolic and immune system functions [17]-[21]. Despite its high nutrient content, the utilization of yellow pumpkin seeds is still relatively low and is often considered agroindustrial waste [22]-[26]. In the development of gummy preparations, yellow pumpkin seeds are used in powder form because they are more practical, allow for more homogeneous mixing, and are more stable to formulate [27], [28]. Sweeteners such as sucrose and stevia also play an important role in the formulation; Sucrose plays a role in the formation of texture, chewiness, and stability, while stevia is a low-calorie natural sweetener with a high level of sweetness that is safe for consumption by various groups of people including diabetics [29]-[31].

In addition to the active ingredients, sweeteners are an important component in multivitamin gummy formulations because they provide a sweet taste and affect the physical characteristics of the preparation, such as texture, chewiness, stability, and consumer acceptance [32]-[35]. Sucrose not only serves as a sweetener, but also plays a role in the formation of the gummy's texture and physical characteristics. Variations in sucrose concentrations can affect the hardness, elasticity, and moisture of the preparation. In addition to sucrose, stevia is used as an alternative natural sweetener in gummy formulations [36]-[38]. In addition to sucrose, stevia is also used as a natural sweetener in multivitamin gummy formulations. Stevia comes from Bertoni's Stevia rebaudiana, has a high level of sweetness, and contains no calories so it can be used as an alternative sweetener [39]-[41]. Variations in stevia concentrations can affect the taste, texture, and level of acceptance of multivitamin gummy preparations [42], [43]. Based on the role of sucrose in the formation of the texture and stability of gummy and stevia as natural sweeteners, variations in the concentrations of the two sweeteners are thought to affect the physical characteristics and acceptance rates of the preparation [44], [45].

Although previous studies have evaluated the physical characteristics, texture, stability, and acceptability of various gummy formulations, studies specifically developing multivitamin gummies based on yellow pumpkin seed powder while comparing different concentrations of sucrose and stevia remain limited. Previous studies have mainly used other active or food materials and evaluated specific types or combinations of sweeteners. Therefore, further research is needed to compare sucrose and stevia at different concentrations in yellow pumpkin seed powder-based gummies to determine their effects on the physical characteristics and acceptability of the preparation. This study is important because the selection of sweetener type and concentration may affect not only sweetness but also the physical characteristics and acceptability of gummy preparations. The approach used in this study was to incorporate yellow pumpkin seed powder into a multivitamin gummy formulation with varying concentrations of sucrose and stevia, followed by evaluation of physical characteristics, microbiological quality, zinc concentration, and acceptability using a hedonic test. This approach is expected to provide information on formulations with favorable physical characteristics and acceptability.

Accordingly, the research questions were: (1) do variations in sucrose and stevia concentrations affect the physical characteristics of yellow pumpkin seed powder-based multivitamin gummies; and (2) which formulation shows the highest acceptability based on the hedonic evaluation? This study aimed to: (1) evaluate the effects of varying sucrose and stevia concentrations on the physical characteristics of yellow pumpkin seed powder (*Cucurbita moschata*) based multivitamin gummies; and (2) determine the acceptability of the formulations based on hedonic evaluation.

2. RESEARCH METHOD

This study is a laboratory experimental research with a quantitative approach to the formulation of multivitamin gummy preparations based on yellow pumpkin seed powder (*Cucurbita moschata*) with a variety of added sweeteners sucrose and stevia. The research included formulas, evaluation of physical characteristics, microbiological tests, determination of zinc levels, and hedonic tests. The study population is yellow pumpkin seeds (*Cucurbita moschata*) which are used as raw materials. The sample is in the form of yellow pumpkin seed powder obtained through sorting, washing, drying, and refining processes. The samples were selected by purposive sampling based on good physical condition, not damaged, and suitable for use as research material.

The ingredients used in the gummy formulation include gelatin, mannitol, glucose syrup, citric acid, coloring, citrus flavor, strawberry flavor, melon flavor, blueberry squeegee, sucrose, stevia, yellow pumpkin seed powder. The tools used include scales, hot plates, thermometers, ovens, decifiers, stirrers, gummy molds, mesh/sieve, and glass glass tools.

Multivitamin gummy is made in nine formulas, namely one control formula (F0) and eight treatment formulas consisting of sucrose and stevia groups. The sucrose group consists of (F1: 30%; F2: 35%; F3: 40%; F4: 45%) and stevia group (F1: 0.30%; F2: 0.35%; F3: 0.40%; F4: 0.45%). The whole formula contains 5% yellow pumpkin seed powder, 18% gelatin, 18% glucose syrup, 5% mannitol, 0.5% citric acid, 1% flavor, 0.3% coloring, and 100% add water.

Table 1. Yellow Pumpkin Seed Powder Multivitamin Gummy Formulation with Sucrose and Stevia Variations

Ingredients	Concentration (% B/V) formula sucrose					Concentration (% B/V) formula stevia			
	F0	F1	F2	F3	F4	F1	F2	F3	F4
Yellow Pumpkin Seed Powder	5%	5%	5%	5%	5%	5%	5%	5%	5%
Sucrose	0	30%	35%	40%	45%	0	0	0	0
Stevia	0	0	0	0	0	0,30%	0,35%	0,40%	0,45%
Gelatin	18%	18%	18%	18%	18%	18%	18%	18%	18%
Glucose Syrup	18%	18%	18%	18%	18%	18%	18%	18%	18%
Mannitol	5%	5%	5%	5%	5%	5%	5%	5%	5%
Citric Acid	0,5%	0,5%	0,5%	0,5%	0,5%	0,5%	0,5%	0,5%	0,5%
Flavors	1%	1%	1%	1%	1%	1%	1%	1%	1%
Dye	0,3%	0,3%	0,3%	0,3%	0,3%	0,3%	0,3%	0,3%	0,3%
Water	add 100								

All ingredients are weighed according to the formula. The gelatin is soaked for the development process in a ratio of 1:20 for 10–15 minutes. Glucose syrup and mannitol are heated to 70–80°C until dissolved, then the expanded gelatin is added while stirring until homogeneous. The temperature of the mixture is lowered to 55–60°C, then the yellow pumpkin seed powder is added and stirred evenly. Next, citric acid, sweeteners (sucrose or stevia), flavors (orange, melon, strawberry, blueberry), and coloring are added until homogeneous. The gummy mass is poured into a silicone mold and cooled at room temperature until it hardens, then removed from the mold.

Physical evaluation of gummy preparations includes organoleptic tests, weight uniformity, cut points, homogeneity, and stability. Organoleptic tests are carried out by observing the physical characteristics of gummy preparations which include shape, color, smell, and taste. Observations are made visually to find out the characteristics of each formula [46]. The weight uniformity test was carried out by weighing 20 units of gummy individually. The data obtained was calculated based on the average weight, standard deviation (SD), and percentage of weight deviation of each unit. Test results are used to determine the uniformity of weight between units of the preparation [28]. The cut point test was carried out on 5 units of gummy by tying the gummy preparation using thread, then given a load gradually until the preparation was cut off. The load at the time of disconnection of the preparation is recorded as the value of the cutting force and expressed in grams (g) [35]. The homogeneity test was carried out on 5 units of gummy by cutting the gummy preparation and observing the inside of the preparation to find out whether there were lumpy, rough, air cavities, or unevenly distributed. The preparation is declared homogeneous if no irregularities are found in the inside of the preparation [28]. The stability test was carried out on 3 units of gummy and used the cycling test technique at three temperature conditions, namely cold temperature 4–8°C, room temperature 25–27°C, and hot temperature of 40°C for 24–72 hours. Observations were made of changes in the shape and texture of the preparation during the testing process [47].

Microbiological tests were carried out using the spread method using SSA media for *Salmonella* sp., NA for ALT, and PDA for AKK. Incubation was carried out at 35–37°C for 24–48 hours and 25–28°C for 3–5 days, then the colonies were counted as CFU/g [48], [49]. Zinc levels were determined using the AAS method in

Formula 3 with a sample weight of 10 grams [50]. The ethical test was conducted because the study involved volunteers on a hedonic test to ensure the safety and willingness of the respondents to voluntarily. The data collection instrument was a hedonic test questionnaire using a 1–5 rating scale. The panelists evaluated the color, aroma, taste, and texture of each formulation. A score of 1 indicated extreme dislike, 2 indicated dislike, 3 indicated moderate liking, 4 indicated liking, and 5 indicated extreme liking. The questionnaire was developed by the researchers based on the organoleptic parameters of the gummy formulation and was used to determine the panelists' acceptance of each formulation [35].

The quantitative data of the cut-off point test results were statistically analyzed using *One Way ANOVA* ($\alpha=0.05$), to find out the differences in characteristics between formulas, before ANOVA analysis was carried out, the data were tested for normality using Shapiro-Wilk and homogeneity test using Levene's Test. If the results of the One-Way ANOVA show a significant difference ($P<0.05$), the analysis is continued with a post hoc test to determine the differences between the formulas. Hedonic test data was obtained from the assessment of 20 respondents on color, aroma, taste, texture using a Likert scale of 1–5. The data of each parameter is calculated based on the average value of respondents' assessments for each formula. Organoleptic data include shape, color, smell, and taste; homogeneity data includes the presence or absence of clumping, rough, or uneven parts; while stability data includes changes in shape and texture during storage. Organoleptic data, homogeneity, and stability were analyzed descriptively by comparing the results of observations between formulas and storage conditions. The results of the analysis are presented in the form of a table to facilitate the comparison of the characteristics of each formula [51], [52].

3. RESULTS AND DISCUSSION

3.1 Yellow Pumpkin Seed Powder Quality Testing

3.1.1 Moisture content

The results of the test of the moisture content of yellow pumpkin seed powder were obtained at 5.93% at a temperature of 105°C for 10 minutes. This value shows that the drying process is able to optimally reduce the water content in the material. This condition supports the stability of the powder during storage because the less water it contains, the less likely it is to cause quality changes due to the activity of microorganisms or chemical reactions. Therefore, the obtained yellow pumpkin seed powder is of good quality to be used as a raw material for multivitamin gummy formulations.

Table 2. Results of Moisture Content Test of Yellow Pumpkin Seed Powder

Sample	Temperature (°C)	Time (minutes)	Moisture Content (%)
Yellow Pumpkin Seed Powder	105°C	10 minutes	5.93%

3.1.2 Returns

The results of processing 250 g of yellow pumpkin seeds produced 135 g of powder with a yield of 54.00%. The value describes the amount of material that can still be retained after the drying, grinding, and sifting stages. The reduced weight of the material is mainly due to the loss of water content, resulting in a drier powder. The resulting yield shows that the processing process is going well and is able to produce an adequate amount of powder.

Table 3. Results of Yellow Pumpkin Seed Powder Yield Test

Starting Weight (g)	Powder Weight(g)	Yields (%)
250	135	54.00%

3.1.3 Powder Microbiology Test

Microbiological testing showed that the yellow pumpkin seed powder met the safety requirements because no *Staphylococcus aureus* (negative) was found, while the ALT and AKK values were still within the permissible limits. These results show that the microbiological quality of the powder is maintained during the processing process, supported by the low moisture content of the powder which makes the environment less conducive to the growth of microorganisms.

Table 4. *Staphylococcus aureus* Test Results

Sample	<i>Staphylococcus aureus</i> Test Results	Remarks
Yellow Pumpkin Seed Powder	Negative(-)	Eligible

Table 5. Total Plate Number (ALT) Test Results

Sample	Dilution	Number of colonies (range 30-300)		Summing up
		I	II	
Yellow Pumpkin Seed Powder	10-1	39	37	3.8 x 10 ²
	10-2	33	35	3.4 x 10 ³
	10-3	31	32	3.1 x 10 ⁴

Table 6. Results of the Khamir Mold Number Test (AKK)

Sample	Dilution	Number of colonies (range 10-150)		Summing up
		I	II	
Yellow Pumpkin Seed Powder	10-1	16	14	1.5 x 10 ² cfu/g
	10-2	13	15	1.4 x 10 ³ cfu/g
	10-3	11	10	1 x 10 ⁴ cfu/g

3.1.4 Particle size

The particle size test results showed the following distribution: mesh 10 (6.18%); mesh 20 (36.42%); mesh 40 (15.74%); mesh 60 (21.05%); and mesh 80 (20.61%). The most particles were retained at 20 mesh, indicating that the powder had a particle size suitable for the purposes of a multivitamin gummy formulation.

Table 7. Particle Size Test Results

Mesh	Weight (g)	Presses
10	6.18	6.18%
20	36.42	36.42%
40	15.74	15.74%
60	21.05	21.05%
80	20.61	20.61%
Total	100	100%

3.2 Physical Evaluation of Multivitamin Gummy Preparations

3.2.1 Organoleptic Tests

The results of organoleptic observations show that the variation in the concentration of sucrose and stevia provides different characteristics of the gummy produced. All formulas have shapes according to the mold. The F0 (control) formula has a greenish-yellow color with a distinctive aroma of yellow pumpkin seeds and a bland taste. The F1–F4 sucrose group produces a flavor from mild sweet to very sweet, while the F4 stevia group begins to give off a typical stevia aftertaste.

Table 8. Results of Organoleptic Tests of Sucrose and Stevia Formulas

Formula	Shape	Color	Aroma	Taste
F0	As per the mold	Greenish yellow	Typical pumpkin	Blandish
Sucrose F1	As per the mold	Yellow	Orange	Light sweetness
Sucrose F2	As per the mold	Red	Strawberry	Sweet
Sucrose F3	As per the mold	Blue	Blueberries	The sweetness of the fit
Sucrose F4	As per the mold	Green	Avocado	Very sweet
Stevia F1	As per the mold	Yellow	Orange	Light sweetness
Stevia F2	As per the mold	Red	Strawberry	Sweet
Stevia F3	As per the mold	Blue	Blueberries	The sweetness of the fit
Stevia F4	As per the mold	Green	Avocado	Sweet + aftertaste

3.2.2 Weight Uniformity Test

Based on the test results, all formulas have relatively uniform weights. Statistical analysis shows that the data is normally distributed, homogeneous, and there are no significant differences between formulas. The results show that the process of mixing ingredients and printing gummy is carried out consistently so that the mass of each gummy is relatively the same, which indicates that the formulation process is going well.

3.2.3 Cut-off Point Test

The cut-off point test results showed an increase in cutting force with increasing concentrations of sucrose and stevia. In the sucrose group, the mean value increased from 101.67 ± 2.89 g in F1 to 105 ± 5 g in F2,

122 ± 6 g in F3, and 127 ± 10.41 g in F4. In the stevia group, the mean value increased from 101.67 ± 2.89 g in F1 to 105 ± 5 g in F2, 121.67 ± 5.77 g in F3, and 123.33 ± 7.64 g in F4. These increases indicate that variations in sweetener concentration may affect the texture and structural strength of the gummy preparation. In the sucrose group, increasing the concentration resulted in a denser gummy texture and a greater cutting force requirement. This is related to the role of sucrose in influencing the physical characteristics of gummy preparations, including hardness, elasticity, and moisture content. This finding is consistent with previous discussions indicating that sucrose functions not only as a sweetener but also affects the formation of texture and physical characteristics of gummy preparations. The statistical analysis further supported these observations.

The cutting point data in both the sucrose and stevia groups were normally distributed and homogeneous. One-Way ANOVA showed significant differences among formulations in the sucrose group ($p = 0.002$) and stevia group ($p = 0.001$). The post hoc test showed significant differences mainly between F0 and F3 and between F0 and F4 in both groups, whereas the comparisons between F0 and F1 and between F0 and F2 were not significant. These findings indicate that changes in texture became more apparent at higher sweetener concentrations. Formula 3 showed a relatively balanced texture, with cutting point values of 122 ± 6 g in the sucrose group and 121.67 ± 5.77 g in the stevia group. Meanwhile, F4 showed the highest cutting point values in both groups, namely 127 ± 10.41 g for sucrose and 123.33 ± 7.64 g for stevia. Therefore, increasing sweetener concentrations, particularly at higher concentrations, may increase the structural strength of the gummy preparation. These findings indicate that the selection of sweetener concentration should consider the balance between sweetness and the desired textural characteristics of the preparation.

Table 9. Sucrose and Stevia Cut Point Test Results

Formula	Sample 1 (g)	Sample 2 (g)	Sample 3 (g)	Mean ± SD
Control (F0)	100	100	110	103.33 ± 5.77
Sucrose F1	105	100	100	101.67 ± 2.89
Sucrose F2	100	105	110	105 ± 5
Sucrose F3	125	115	125	122 ± 6
Sucrose F4	130	135	115	127 ± 10.41
Stevia F1	100	100	105	101.67 ± 2.89
Stevia F2	100	110	105	105 ± 5
Stevia F3	115	125	125	121.67 ± 5.77
Stevia F4	130	115	125	123.33 ± 7.64

3.2.4 Homogeneity Test

The homogeneity test results showed that all multivitamin gummy formulations, including the sucrose and stevia groups, exhibited homogeneous characteristics. The test was performed by cutting the gummy preparation and observing its internal appearance for the presence of lumps, rough areas, air cavities, or uneven portions. Based on the observations, none of these irregularities were found in any of the formulations, indicating that all preparations were homogeneous. The consistent homogeneity observed across all formulations indicates that the mixing process and pouring of the gummy mass into the molds were performed uniformly. The results also indicate that variations in sucrose and stevia concentrations did not cause the formation of lumps, rough areas, air cavities, or uneven portions in the preparations. This finding suggests that the components of the gummy mass were well distributed, resulting in preparations with uniform physical characteristics. Therefore, all formulations, including F0, sucrose F1–F4, and stevia F1–F4, exhibited homogeneous characteristics based on visual observation.

Table 10. Results of Sucrose and Stevia Homogeneity Test

Formula	Results
F0	Homogeneous
Sucrose F1	Homogeneous
Sucrose F2	Homogeneous
Sucrose F3	Homogeneous
Sucrose F4	Homogeneous
Stevia F1	Homogeneous
Stevia F2	Homogeneous
Stevia F3	Homogeneous
Stevia F4	Homogeneous

3.2.5 Stability Test

The stability test results showed that all gummy formulations were able to maintain their physical characteristics during testing at cold temperature (4–8°C) and room temperature (25–27°C). During the

observation period, no significant changes in shape, aroma, or homogeneity were observed, and no fungal growth was detected. These results indicate that all formulations exhibited good physical stability under cold and room-temperature conditions during the testing period. Under the hot temperature condition of 40°C, all formulations underwent melting and a slight darkening of color, while no changes in aroma were observed. These changes indicate that the gummy preparations were more sensitive to exposure to high temperatures. Melting at 40°C may be associated with the properties of the gelling components, which can experience a reduction in structural strength when exposed to elevated temperatures. This condition causes the gummy structure to become softer and eventually melt.

The results indicate that storage temperature is an important factor in maintaining the physical characteristics of gummy preparations. The stability of the formulations under cold and room-temperature conditions suggests that these conditions are more suitable for maintaining the shape and texture of the preparations. In contrast, exposure to 40°C caused physical changes, indicating a limitation in the stability of the preparations under high-temperature conditions. Therefore, all formulations exhibited good physical stability at 4–8°C and 25–27°C but were unstable when exposed to 40°C during the testing period. These findings should be considered when determining the appropriate storage conditions for multivitamin gummies to maintain their physical characteristics.

3.3 Microbiological Test of Gummy Preparations

Microbiological testing was conducted on the F3 formulations from the sucrose and stevia groups to evaluate the microbiological quality of the preparations based on *Salmonella* sp., Total Plate Count (ALT), and Yeast and Mold Count (AKK). The results showed that *Salmonella* sp. was not detected in either the sucrose F3 or stevia F3 gummy formulations, indicating negative results for *Salmonella* sp. in both formulations. For the ALT test, sucrose F3 at the 10⁻¹ dilution produced 2 colonies in replicate I and 0 colonies in replicate II, while the 10⁻² dilution produced 1 colony in replicate I and 0 colonies in replicate II. In stevia F3, the 10⁻¹ dilution produced 2 colonies in replicate I and 0 colonies in replicate II, while the 10⁻² dilution produced 1 colony in replicate I and 0 colonies in replicate II. These results indicate a low number of colonies in both formulations.

For the AKK test, sucrose F3 at the 10⁻¹ dilution produced 2 and 4 colonies in the respective replicates, while the 10⁻² dilution produced 2 and 0 colonies. In stevia F3, the 10⁻¹ dilution produced 9 and 7 colonies, while the 10⁻² dilution produced 8 and 2 colonies. These results indicate the presence of yeast and mold growth at relatively low levels in both formulations. Based on the test results, the ALT and AKK results of both F3 formulations met the acceptance limits applied in the study, while *Salmonella* sp. showed negative results. These findings indicate that the two tested F3 formulations had acceptable microbiological quality based on the parameters evaluated. However, these findings only represent the microbiological condition of the tested sucrose F3 and stevia F3 formulations and cannot be generalized to all gummy formulations.

Table 11. *Salmonella* sp test result of sucrose and stevia F3

Sample	<i>Salmonella</i> sp test result	Remarks
Sucrose F3	Negative (-)	Meets requirements
Stevia F3	Negative (-)	Meets requirements

Table 12. Total Plate Number (ALT) Test Results of Sucrose and Stevia F3

Sample	Dilution Level	Number of colonies		Remarks
		I	II	
Sucrose F3	10 ⁻¹	2	0	Meets requirements
	10 ⁻²	1	0	Meets requirements
Stevia F3	10 ⁻¹	2	0	Meets requirements
	10 ⁻²	1	0	Meets requirements

Table 13. Results of the Khamir Mold Number Test (AKK) Sucrose and Stevia F3

Sample	Dilution Level	Number of colonies		Remarks
		I	II	
Sucrose F3	10 ⁻¹	2	4	Meets requirements
	10 ⁻²	2	0	Meets requirements
Stevia F3	10 ⁻¹	9	7	Meets requirements
	10 ⁻²	8	2	Meets requirements

3.4 Zinc Levels Test (AAS)

Zinc content was determined using the Atomic Absorption Spectrophotometry (AAS) method in the F3 formulations of the sucrose and stevia groups using a 10-g sample weight. The analysis showed that the zinc content was 2.9761 mg/L in the sucrose F3 gummy and 2.168 mg/L in the stevia F3 gummy. These results

indicate that zinc derived from yellow pumpkin seed powder was still detected after the formulation process into multivitamin gummies. The difference in zinc content between the two formulations indicates variation in the measured zinc levels between the gummies containing sucrose and stevia. The higher zinc content observed in sucrose F3 compared with stevia F3 may be associated with differences in formulation composition and processing conditions. However, because zinc content was only determined in the F3 formulation from each sweetener group, these differences cannot be used to conclude that the type of sweetener directly caused the difference in zinc content.

These findings indicate that yellow pumpkin seed powder can serve as a source of zinc in the development of multivitamin gummy preparations. The use of AAS enables quantitative determination of zinc in the formulated preparations. Therefore, the zinc analysis provides preliminary information regarding the presence of zinc in the sucrose F3 and stevia F3 formulations.

Table 14. Formula 3 Gummy Preparation Zinc Test Results

Sample	Parameters	Results	Units
Sucrose F3	Zinc content	2.9761	Mg/L
Stevia F3	Zinc content	2.168	Mg/L

3.5 Statistical Analysis of Cut-Off Points

The Shapiro-Wilk normality test showed normal distributed data in both the sucrose ($W = 0.961$; $p = 0.718$) and stevia ($W = 0.953$; $p = 0.566$) groups. The Levene's Test homogeneity test showed homogeneous data in the sucrose ($F = 1.89$; $p = 0.188$) and stevia ($F = 0.839$; $p = 0.531$) groups. The results of the One-Way ANOVA showed that there was a significant difference between the formulas in the sucrose group ($F = 9.70$; $df1 = 4$; $df2 = 10$; $p = 0.002$) and stevia ($F = 10.6$; $df1 = 4$; $df2 = 10$; $p = 0.001$). Post Hoc tests showed that there was a significant difference in the F0 vs F3 ($p = 0.037$ sucrose; $p = 0.017$ stevia) and F0 vs F4 ($p = 0.009$ sucrose; $p = 0.010$ stevia), while the F0 vs F1 and F0 vs F2 comparisons showed no significant difference ($p > 0.05$). This suggests that the addition of sucrose sweetener at concentrations of 40% and above significantly increased the mechanical strength of the gummy compared to controls.

3.6 Hedonic Test

The hedonic test was conducted on 20 respondents to determine the level of acceptance of the color, aroma, taste, and texture of the gummy formulations. The results showed that formula F3 obtained the highest mean score in both the sucrose and stevia groups, with scores of 4.63 and 4.45, respectively, on a 1–5 scale. In the sucrose group, the mean score increased from 3.91 for F1 to 4.29 for F2 and reached the highest value of 4.63 for F3, followed by a decrease to 4.25 for F4. In the stevia group, the mean score increased from 3.75 for F1 to 4.15 for F2 and reached 4.45 for F3, followed by a decrease to 4.11 for F4.

These results indicate that F3 had the highest level of acceptance compared with the other formulations within each sweetener group. The increase in mean scores from F1 to F3 indicates that increasing the sweetener concentration up to the F3 concentration may improve respondent acceptance of the gummy preparation. However, the decrease in scores at F4 indicates that further increases in sweetener concentration do not necessarily improve the level of liking. This finding suggests that a certain sweetener concentration may provide better acceptance of the gummy characteristics.

In sucrose F3, the highest mean score was observed for taste at 4.80, followed by color at 4.70, texture at 4.65, and aroma at 4.35. Meanwhile, in stevia F3, the highest scores were observed for color and taste, both at 4.55, followed by aroma and texture at 4.35 each. These results indicate that color and taste received relatively high acceptance scores in the F3 formulations.

Table 15. Hedonic Test Results of Gummy Multivitamin

Formula	Color	Aroma	Taste	Texture	Average
Control (F0)	2.35	3.80	2.75	4.10	3.25
Sucrose F1	3.80	4.00	3.85	4.00	3.91
Sucrose F2	4.25	4.20	4.35	4.35	4.29
Sucrose F3	4.70	4.35	4.80	4.65	4.63
Sucrose F4	4.25	4.20	4.20	4.35	4.25
Stevia F1	3.50	3.95	3.55	4.00	3.75
Stevia F2	4.20	4.10	4.10	4.20	4.15
Stevia F3	4.55	4.35	4.55	4.35	4.45
Stevia F4	4.15	4.10	4.00	4.20	4.11

The results of the hedonic test showed that there was a variation in the level of preference for each multivitamin gummy formula. The average value of the hedonic test of each formula is presented in Figure 1.

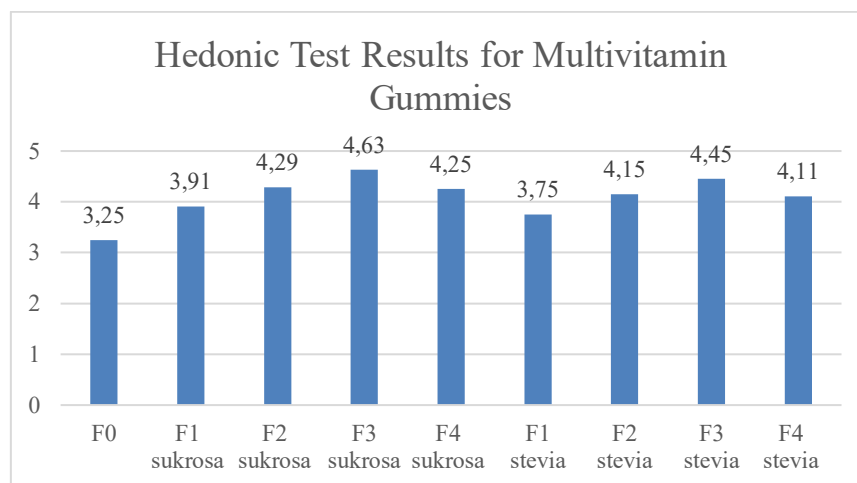


Figure 1. Mean hedonic scores of gummy multivitamin formulations with different sucrose and stevia concentrations

The novelty of this study lies in the development of multivitamin gummies based on yellow pumpkin seed powder (*Cucurbita moschata*) by comparing different concentrations of sucrose and stevia as added sweeteners. The study evaluated not only the physical characteristics of the preparations but also their microbiological quality, zinc content, and acceptability through a hedonic test. The results showed that F3 achieved the highest level of acceptance within each sweetener group, indicating its potential for further development. Practically, the findings indicate that yellow pumpkin seed powder can be used as an ingredient in the development of multivitamin gummy preparations. The F3 formulations in both the sucrose and stevia groups showed the highest acceptance based on the hedonic test and demonstrated acceptable physical characteristics and microbiological results within the evaluated parameters. However, the stability test showed that the preparations underwent melting at 40°C, indicating that storage conditions should be considered to maintain the physical characteristics of the gummies. This study has several limitations. Microbiological and zinc content testing was conducted only on the F3 formulations of the sucrose and stevia groups; therefore, the results cannot represent all developed formulations. In addition, the hedonic test involved 20 respondents and was analyzed descriptively based on mean scores. Further studies are recommended to evaluate microbiological quality and zinc content in all formulations, involve a larger number of panelists, and conduct stability testing under a wider range of storage conditions and periods to obtain more comprehensive information regarding the stability of the preparations.

4. CONCLUSION

Variations in sucrose and stevia concentrations resulted in differences in the physical characteristics and acceptability of multivitamin gummies based on yellow pumpkin seed powder (*Cucurbita moschata*). Formula F3 showed the highest level of acceptance within each sweetener group, with mean scores of 4.63 for sucrose F3 and 4.45 for stevia F3. The results also showed that the sucrose F3 and stevia F3 formulations exhibited acceptable physical characteristics and microbiological quality based on the evaluated parameters. AAS analysis detected zinc in both tested F3 formulations, with concentrations of 2.9761 mg/L in sucrose F3 and 2.168 mg/L in stevia F3. Therefore, yellow pumpkin seed powder has potential for further development as an ingredient in multivitamin gummy preparations with sucrose and stevia sweetener variations.

ACKNOWLEDGEMENTS

The author would like to thank the Pharmacy Study Program, Faculty of Medicine and Health Sciences, Adiwangsa University of Jambi, for the laboratory facilities provided, as well as to all parties and volunteers who have assisted in the implementation of this research.

AUTHOR CONTRIBUTIONS

Conceptualization, Sekar Banowati, Rizkha Dwi Nurhalyza Putri; Methodology, Sekar Banowati, Rizkha Dwi Nurhalyza Putri; Formal Analysis, Sekar Banowati, Rizkha Dwi Nurhalyza Putri; Investigation, Sekar Banowati, Rizkha Dwi Nurhalyza Putri; Resources, Sekar Banowati, Rizkha Dwi Nurhalyza Putri; Data Curation, Sekar Banowati, Rizkha Dwi Nurhalyza Putri; Writing – Original Draft Preparation, Sekar Banowati, Rizkha Dwi Nurhalyza Putri; Writing – Review & Editing, Sekar Banowati, Rizkha Dwi Nurhalyza Putri, and

Apt. Rahmadevi, S.Si., M.Farm.; Visualization, Rizkha Dwi Nurhalyza Putri; Supervision, Apt. Rahmadevi, S.Si., M.Farm.; Project Administration, Sekar Banowati; Funding Acquisition, None.

CONFLICTS OF INTEREST

The author(s) declare no conflict of interest.

INFORMED CONSENT STATEMENT

Consent after explanation was obtained from all volunteers before the implementation of the hedonic test. Volunteers are provided with an explanation of the objectives and procedures of the research and the right to voluntarily participate in or terminate participation in the research. All volunteers gave their consent before taking the hedonic test. This research has obtained an Ethical Feasibility Information from the Health Research and Development Ethics Committee of the Jambi Ministry of Health Polytechnic with the number LB.02.06/2/0787/2026, which was set on June 12, 2026 and valid until June 12, 2027. All volunteers have had the opportunity to understand the research information and ask questions before giving consent. A total of 20 volunteers stated that they were willing to participate in the study voluntarily and had signed an informed consent form before the study began. All images in this article have been authorized and are the property of the authors.

USE OF ARTIFICIAL INTELLIGENCE (AI)-ASSISTED TECHNOLOGY

The authors declare that no artificial intelligence (AI) tools were used in the generation, analysis, or writing of this manuscript. All aspects of the research, including data collection, interpretation, and manuscript preparation, were carried out entirely by the authors without the assistance of AI-based technologies.

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