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Development and Quality Evaluation of Immune-Boosting Jelly Candy Using Natural Ingredients.

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ABSTRACT

This study aimed to develop jelly candy with natural ingredients that have immune-boosting properties. Four candy samples were prepared from ingredients including lemon, beetroot, carrot, orange, pomegranate, strawberry, ginger, turmeric, black pepper, and gelatin. Two samples were sweetened with natural honey, and two with stevia sugar. Traditional gelatin candy from the local market was used for comparison. The samples were subjected to analysis of chemical quality properties, proximate composition, phytochemical analysis, mineral content, microbial analysis, and sensory evaluation. The most important results obtained showed that the prepared samples contained good levels of protein, fiber, and potassium, which were 6.87±0.009%, 3.55±0.003%, and 64±2 ppm, respectively. The beetroot, pomegranate, and strawberry samples had excellent iron content (35±2 and 31±2 ppm) for the honey-sweetened and stevia-sweetened samples, respectively. The preliminary screening results for phytochemical compounds showed that the prepared samples were rich in phenols, glycosides, and tannins (+++), while the samples sweetened with natural honey had excellent saponin content (+++). Microbial analysis revealed that the samples were free of coliform bacteria and E. coli. Sensory evaluation results revealed that the participants preferred the stevia-sweetened samples in all tested attributes, including color, taste, flavor, and overall acceptability, with a (very good) rating. The study recommended the development of a functional food industry based on natural food ingredients rich in macro- and micronutrients and active chemical compounds.

KEYWORDS: jelly candy, immunity booster, functional food, phytochemical compounds, coliform bacteria..

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1.INTRODUCTION

The confectionery industry is one of the largest global food sectors; however, traditional jelly candies remain nutritionally poor due to their formulation, which typically relies on high amounts of sucrose and glucose, combined with gelling agents such as gelatin, starch, and corn syrup, as well as organic acids, colorings, and flavorings. Such compositions provide minimal nutritional value and may contribute to several health concerns, including dental caries, increased cravings, elevated blood glucose levels, and a higher risk of developing type 2 diabetes (Amer and Abd El-Rahman, 2023; Marfil et al., 2012; Burey et al., 2009; Tarahi et al., 2024). These limitations have raised awareness of the need to reformulate confectionery products into healthier alternatives.

In response, the concept of functional foods has gained considerable interest. Functional foods are designed to offer health benefits beyond basic nutrition by supplying essential macro- and micronutrients, antioxidants, and bioactive compounds that play vital roles in supporting immunity, reducing inflammation, and enhancing overall well-being (Singh et al., 2023; Abdallah et al., 2023). The increased demand for natural, health-promoting foods has encouraged the use of fruits and vegetables as alternative ingredients in food product development due to their richness in vitamins, minerals, polyphenols, and fiber (Devirgiliis et al., 2024).

In addition, herbs and natural plant extracts have emerged as promising contributors to functional food innovations because they contain diverse bioactive constituents—such as terpenoids, flavonoids, and beta-glucans—known for their immunomodulatory and protective effects. Probiotics, prebiotics, and plant-derived melatonin have also demonstrated potential in reducing inflammation and improving gut and immune health (Gasmi et al., 2023). Likewise, natural sweeteners and fruits such as pomegranate, citrus, and ginger provide valuable antioxidants and micronutrients that support cardiovascular, metabolic, and cognitive health (Vishwaarma et al., 2022; Stephen et al., 2023). Taken together, incorporating fruits, vegetables, herbs, and natural sweeteners into confectionery products represents a practical strategy to enhance their functional value while meeting the growing consumer demand for healthier and more natural alternatives. Therefore, this study aimed to develop an innovative functional jelly candy enriched with selected fruits, herbs, and natural sweeteners, with the objective of improving its nutritional profile and providing immune-boosting benefits compared to traditional commercial jelly products.

2.MATERIALS AND METHODS

2.1.Purchase of raw materials:

Fruits and vegetables were purchased from the Aljemail city, and the remaining ingredients, such as turmeric, black pepper, honey, and gelatin, were purchased from herbalists and local markets in the Aljemail area.

2.2.Preparation of samples:

Four formulas of jelly candy were prepared for this study. The main ingredients and proportions of samples (1) and (3) were shown in table (1). The ingredients of the two samples are the same, but sample (1) was sweetened by natural bee honey, and sample (3) was sweetened by stevia sugar (to meet the demands of diabetic people and followers of low-calorie, low-carb diets). Firstly, lemon, apple, rosemary, fresh ginger, and mint were washed, removing the outer peels and inner seeds of the lemon and removing the inner seeds of the apples, and adding the remaining ingredients, such as turmeric, black pepper, honey (for sample 1), or stevia (for sample 3). All ingredients were then weighed according to the required proportions shown in table (1) and added to an electric blender and blended for 5 minutes. A plastic strainer was used to filter the juice after it had been blended. Water was placed in a stainless-steel pot, and gelatin was added and dissolved over low heat (about 80°C for 3 minutes) with continuous stirring. The prepared gelatin was then added to the prepared mixture of fruit and herbs and stirred well. The juice was then extracted using a sterilized syringe, poured into silicone molds, and placed in the freezer for at least 10 to 15 minutes.

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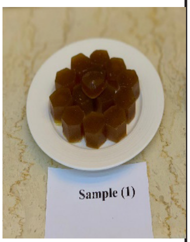
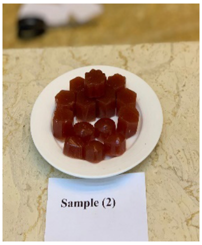
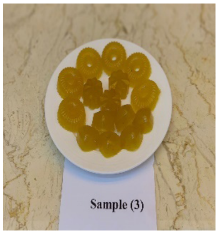
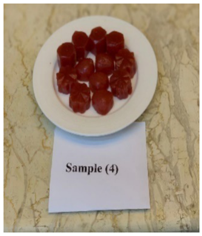
Samples (2) and (4) were prepared by washing and peeling pomegranates, carrots, beets, strawberries, lemons, and oranges, removing the inner seeds, and adding the remaining ingredients: turmeric, black pepper, honey (sample 2), or stevia (sample 4). All ingredients were then weighed according to the required proportions shown in table (1) and blended in an electric blender for at least 5 minutes. The juice was blended and then filtered through a plastic sieve. Water was placed in a stainless-steel pot, gelatin was added, and the mixture was dissolved with continuous stirring at a temperature not exceeding a boil just to dissolve the gelatin (about 80°C for 3 minutes). The dissolved gelatin was then added to the juice mixture and stirred well. Then the mixture was taken using a sterile syringe and placed in clean silicone molds and placed in the freezer for at least 10 to 15 minutes.

Note: Halal bovine gelatin powder (Silver) from Amin Gelatin Factories, 6th of October City, Egypt, was used in preparing these samples. Production date: 2024; expiry date: 5 years from the date of production.

Halal commercial jelly candy (HARIBO/made in Türkiye) was used as a control sample.

Table (1): Iingredients and proportion of samples of the jelly candy

Ingredients	Sample (1)	Sample (2)	Sample (3)	Sample (4)
Lemon	11.09%	4.94%	16.43%	5.63%
Apples	33.28%	-	37.91%	-
Ginger	0.44%	0.48%	0.50%	0.169%
Mint	0.44%	-	0.53%	-
Rosemarry	0.26%	-	0.25%	-
Turmeric	0.11%	0.19%	0.12%	0.022%
Blak pepper	0.02%	0.009%	0.03%	0.011%
Pomegranate	-	14.82%	-	16.91%
Beetroot	-	2.47%	-	2.81%
Strawberry	-	19.76%	-	22.55%
Orange	-	19.76%	-	22.55%
Carrots	-	5.93%	-	6.76%
Stevia sugar	-	-	3.79%	2.81%
Hony	18.86%	14.82%	-	-
Gelatine	13.31%	8.40%	15.17%	9.58%
Water	22.19%	8.89%	25.27%	10.198%
Final product	 Sample (1)	 Sample (2)	 Sample (3)	 Sample (4)

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2.3.Chemical Analysis:

All chemical and quality analyses were carried out according to approved methods of the Association of Official Analytical Chemists (AOAC 2005).

2.4.Quality analysis:

Total Soluble Solids (T.S.S.) of the juice mixture was determined using a Rhino Brix refractometer HR-150N/ Rhino technology (Brix scale 0-80%). Titerable Acidity: Was determined by the titration method using NaOH (0.1 N) and phenolphthalein as an indicator. PH: PH measurement was conducted using a pH Socket/BNC Socket.

2.5.Proximate Composition:

Moisture content: This was determined using an ATG high-temperature oven (Shanghai/China) at 135 degrees for 2 hours. Ash content: Ash content was determined using a ZE electric muffle furnace (Italy) at 550°C for 6 hours. Protein: This was determined using the micro Kjeldahl method, which includes digestion, distillation, and titration. Fat: This was determined using Soxhlet. Carbohydrate: It was measured using the Anthrone technique as outlined by Plummer (1990). Carbohydrates underwent dehydration using concentrated sulfuric acid (H_2SO_4) to produce furfural. Anthranilic, the enol tautomer of anthrone, was the reagent's active form. It was condensed with the carbohydrate furfural derivative to create a green color in diluted form that could be measured by calorimetry solutions.

2.6.Mineral Analysis:

A flame photometer (BWB Technologies/England) was used in the determination of minerals. For each type of mineral, the concentration was measured against the standard curve.

2.7.Phytochemical Screening:

Phytochemical screening: The technique outlined by Harborne (1998) was used to identify the phytochemical. Polyphenols: This was estimated according to the method of Gutfinger (1981), where the polyphenol compounds were extracted using alcohol (methanolic extract) and then estimated with Folin-Ciocalteau reagent. The extraction was assessed at 695 nm in comparison to the calibration curve. The antioxidant was evaluated through the phosphomolybdenum technique described by Perietop et al. (1999).

2.8.Energy Content:

The energy content was determined via a CALO-3 Bomb calorimeter, which is used to measure the heat of combustion when placed in a reaction container surrounded by water. The temperature of the water surrounding the reaction container rises as the material and oxygen gas are heated until the substance combusts; the combustion temperature is then determined. according to the following equation:

$\Delta U = qv = mcv\Delta T$

where:

- m = mass of water

2.9.Microbiological Analysis:

Compact Dry TC, a quick testing kit designed for measuring aerobic colony counts, coliform, and E. coli, has been developed by Nissui Pharmaceutical Co. for food applications and was used to evaluate the microbial load. The plates are sterilized in advance and contain culture medium, a gelling agent that liquefies in lower temperatures, and a redox indicator that changes color for easier counting (De Vaugelade et al., 2017).

Statistical analysis: All results of this study were subjected to statistical analysis using the SPSS program (version 21) for three replicates and were expressed as mean ± standard deviation.

3.RESULTS AND DISCUSSION

3.1.Quality Analysis:

Table (2) Quality analysis of juice mixture before adding gelatin

Sample	Mean ± SD		
	TSS	**Acidity**	**pH**
Sample 1	19.6±0.3	0.09±0.002	3.44±0.00
Sample 2	19.4±0.2	0.05±0.001	3.94±0.02
Sample 3	12.0±0.1	0.10±0.001	3.36±0.01
Sample 4	13.0±0.3	0.04±0.003	3.95±0.02
P-value	<0.001	<0.001	<0.001
Comment	S	S	S

Table (2) above illustrated the quality properties (TSS, pH, and acidity) of the juice mixture before adding gelatin. Samples 1 and 2, containing natural honey, had higher total soluble solids (TSS) than samples 3 and 4, which contained stevia sugar, indicating that honey played a role in raising TSS. Samples 1 and 3 also exhibited higher acidity and lower pH due to their higher lemon content. With p-values 0.001 below the 0.05 significant level, it was clear that there was a significant difference (at P > 0.05) between samples in the mean of TSS, acidity, and pH. In comparison to previous studies, Basiony et al. (2023), in a study of using pomegranate, beetroot, and strawberry juice to produce yogurt, found that the acidity and pH value of the fresh juice was 4.66±0.01 to 4.75±0.01, and the purée varied from 0.85±0.01 to 1.03±0.01. The results of this study differed from what Basiony et al. (2023) found. This difference may be due to the difference in components and proportions used in this study.

3.2.Proximate Composition:

Table (3) Chemical composition of jelly candy samples (%)

Sample	Mean ± SD					
	Moisture content%	Ash%	Protein%	Fats%	Fibre%	Carbohydrates%
Sample1	68.15±0.005	0.55±0.003	4.76±0.003	3.41±0.01	3.55±0.003	19.58±0.005
Sample2	73.02±0.032	1.87±0.002	6.87±0.009	2.92±0.013	3.02±0.003	12.02±0.003
Sample3	74.85±0.015	0.48±0.004	2.84±0.003	3.75±0.009	2.94±0.006	15.14±0.004
Sample4	79.92±0.034	1.81±0.012	4.91±0.007	2.81±0.003	2.94±0.003	7.61±0.004
Control	5.50±0.007	0±0.001	1.99±0.008	3.98±0.004	2.54±0.002	85.99±0.005
P-value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Comment	S	S	S	S	S	S

One-way ANOVA was used at the 0.05 significant level, with S ≡ significant difference.

Table (3) shows the chemical composition of jelly candy. Sample 1, which consisted of lemon, apple, mint, rosemary, curcumin, black pepper, and honey, had the lowest moisture content and highest fiber and carbohydrate content among the studied jelly candy samples, while the commercial jelly sample had the highest carbohydrate and fat content and lowest moisture content (85.99±0.005, 3.98±0.004, and 5.50±0.007%), respectively. It was noted that the commercial sample was extremely free of ash (0.00), which means that the percentage of minerals and vitamins is very low. From the results shown in the above table, it was also clear that samples 2 and 4, which contained beetroot, pomegranate, and strawberry, were characterized by higher levels of ash and protein (1.87±0.002, 1.81±0.012 and 6.87±0.009, 4.91±0.007%) for honey- and stevia-sweetened samples, respectively. Amer and Abd El-Rhman (2023), in a study aimed at developing a healthy gelatin dessert, found that the protein content of the prepared samples ranged from 2.2 to 3.7% compared to the control sample, which was 7.9%. They also found that the total energy content of the prepared samples ranged from 18.3 to 33.49 kcal/100 g compared to the control sample, which recorded 294 kcal/100 g. Another study aimed to develop a healthy fruit-based gelatin dessert by Teixeira-Lemos et al. (2021) found that the protein content of the prepared samples ranged between 4.04 and 3.25 grams per 100 grams. Sugar content was 8.81 and 4.63 grams per 100 grams, compared to the control sample of 58 grams per 100 grams. Furthermore, the analysis results in the table (3) showed significant differences in the chemical composition of the developed jelly candy compared to the commercial one in terms of carbohydrates, ash (which reflects mineral and vitamin content), and protein. These differences could represent a good advantage to meet the different nutritional and sensory requirements of consumers. Furthermore, it's obvious that the developed jelly candy samples were characterized by their high lev-

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els of dietary fiber (3.55 to 2.94%). Dietary fiber plays a fundamental role in the immune response, as it improves beneficial intestinal microflora, which improves bowel movement. When intestinal microflora ferment dietary fiber, their numbers multiply, thus reducing inflammation and enhancing immunity (Cohen & Elinav, 2023; Yang et al., 2020).

From the results shown in Table (3), the commercial jelly candy contained a very high sugar content and a very low ash content, indicating its low mineral and vitamin levels. Therefore, excessive consumption of commercial jelly candy may negatively affect public health due to their high sugar content and additives, especially colors, as well as their association with tooth decay, high blood sugar, and the risk of obesity. Furthermore, their low nutritional value contradicts the consumer's tendency to consume healthier foods, while the newly developed formulations in this study showed high nutritional value in terms of protein, ash, and fat content and a suitable energy content, especially in the samples sweetened with stevia sugar.

3.3.Total Energy:

Table (4) Total Energy content of jelly candy (kcal/100g)

Sample	Mean ± SD
	Total energy kcal/100g
Sample1	128.06±0.09
Sample2	101.51±0.37
Sample3	105.66±0.07
Sample4	75.74±0.74
Control	387.48±0.39
P-value	<0.001
Comment	S

One-way ANOVA was used at the 0.05 significant level, with S ≡ significant difference.

Table 4 shows the energy contents of the new jelly candy samples compared to the commercial ones. The commercial sample had a very high energy content (387.88±0.39), due to its high carbohydrate content (Table 4), while the improved jelly candy samples showed lower energy contents compared to the commercial sample. As expected, samples sweetened with stevia had the lowest energy content, which makes them a good choice for those following a low-carb diet and diabetics, while the samples sweetened with natural honey showed good levels of energy, making it a suitable healthy choice compared to sweets containing white sugar, according to the health system that many consumers are currently adopting, especially with regard to the calorie content of foods, which may lead to many health disorders (Amer and Abd El-Rhman, 2023). Calder and Kew (2002) indicated that a deficiency in total energy or one or more of the essential nutrients weakens the immune system and increases susceptibility to disease. It is likely that these elements have a fundamental role in the molecular and cellular response of the immune system, and thus the availability of these elements enhances the functions of the immune system's operations and enhances infection resistance.

3.4.Mineral Content:

Table (5) Mineral content of jelly candy (ppm)

Sample	Mean ± SD		
	Sodium	Potassium	Iron
Sample1	9±2	32±2	3±2
Sample2	13±2	64±2	35±2
Sample3	9±1	33±3	3±1
Sample4	11±2	58±1	31±2
Control	25±3	6±0	3±2
P-value	<0.001	<0.001	<0.001
Comment	S	S	S

One-way ANOVA was used at the 0.05 significant level, with S ≡ significant difference.

Table (5) showed the percentage of minerals (ppm) in jelly candy samples. Samples 2 and 4, containing beetroot, strawberry, and pomegranate, were distinguished by their higher levels of sodium, potassium, and iron among the samples prepared in this study, while the control sample showed the highest level of sodium and the lowest levels of both potassium and iron. The control sample contained the highest sodium level (25 ppm), and sample 2 had the highest potassium level (64), and sample 3 had

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the highest iron level (35 ppm). Amer & Abd El-Rhman (2023) found that the percentage of iron, sodium, and potassium in samples of jelly sweets prepared from some fruits ranged between Fe: 8.25 to 10.05, Na: 35.3 to 90.3, and K: 1191 to 1229 mg/100 g, respectively, while the control sample recorded percentages of 5.16, 10.9, and 780.3 for the same elements, respectively. Minerals were important micronutrients linked to numerous aspects of human health (Amer & Abd El-Rhman, 2023). For example, potassium played a key role in insulin resistance and type 2 diabetes, according to the U.S. Department of Agriculture (2020-2025), while iron is crucial for preventing anemia and aiding children's growth (Wang et al., 2019). The immune system needs minerals such as iron, zinc, and magnesium, which participate with vitamins A and D in the synthesis of nucleotides and nucleic acids (DNA and RNA), which are regulators of the genetic sequence of immune cells and play an important role in the maturation and response of immune cells (Calder, 2013).

3.5.Phytochemical Analysis:

Table (6) Phytochemical screening for jelly candy

	Sample 1	Sample 2	Sample 3	Sample 4	Control
Flavonoid	+++	-ve	+++	++	+
Phenols	++	+++	+++	+++	+
Alkaloids	-ve	-ve	-ve	-ve	+++
Glycosides	+++	+++	+++	+++	+++
Saponin	+++	+++	+	+	-ve
Tannins	+++	+++	+++	+++	+

-ve Negative +weak ++ medium +++ strong

Table (6) showed the initial screening of active chemical compounds in the new jelly candy samples compared to commercial jelly candy. The results showed that the manufactured gelatine candy samples were richer in phenols, glycosides, and tannins than the commercial sample. It is also noted that the samples sweetened with natural honey had the highest saponin content. The commercial sample was low in flavonoids, phenols, and tannins; did not contain saponins; and had a high content of alkaloids and glycosides. Many previous studies had focused on developing jelly sweets by adding fruits, medicinal herbs, and propolis, which are rich in antioxidants and active phytochemicals (Al-Jaloudi et al., 2025; Roudbari et al., 2024; Tarahi et al., 2024; Masri, 2023).

Table (7) Polyphenols and antioxidant

Sample	Mean ± SD	
	Polyphenols(mg/QE/g)	Antioxidants(mg/GAE/g)
Sample1	111.1±13.91	0.09±0.06
Sample2	135.64±4.36	0.19±0.012
Sample3	120.68±5.98	0.07±0.011
Sample4	131.98±20.39	0.09±0.022
Control	0.94±1.4	0.05±0.001
P-value	<0.001	0.002
Comment	S	S

One-way ANOVA was used at the 0.05 significant level, with S ≡ significant difference.

Table (7) showed the content of polyphenols and antioxidant activity of the improved jelly candy samples. It is clear from the table above that the prepared samples were rich in polyphenols, especially samples (2,4) containing beetroot, pomegranates, and strawberries; this may be due to these items being rich in these compounds, which makes them the best combination in terms of active chemical compounds compared to the control sample (commercial jelly candy), which was

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very poor in polyphenols and antioxidant activity. The above table also shows that there is a significant difference between the samples in the mean of polyphenols and antioxidants (p-values are 0.001). Rubio-Arraez et al. (2018) found that the antioxidant activity values of jelly samples in which sugar was replaced by other sweeteners were found to range from 8.3 to 9.9 mg/100 g. In another study, Teixeira-Lemos et al. (2021) prepared gelatin desserts from orange, honey, and mixed berries. It was found that both samples had antioxidant capacity, while the mixed berry dessert was distinguished by higher antioxidant activity. Compared to the findings of the current study, the antioxidant capacity of the prepared samples was significantly lower than that reported in the two previous studies. This may be due to the differences in the components and their composition in the prepared gelatin desserts.

3.6.Sensory Evaluation:

Table (8) Sensory evaluation

Sample	Mean ± SD			
	Colour	Taste	Flavour	Over all acceptability
Sample1	4.13±1.049	2.30±0.997	2.33±1.284	2.65±1.022
Sample2	4.27±0.989	2.82±1.049	2.65±1.117	3.28±1.059
Sample3	4.50±0.911	3.75±1.174	3.72±1.151	4.07±1.133
Sample4	4.65±0.840	4.28±0.885	4.27±0.821	4.53±0.791
P-value	0.015	<0.001	<0.001	<0.001
Comment	S	S	S	S

Two independent sample t-tests were used at the 0.05 significance level. If the p-value < 0.05 (significant difference), then the mean is 4.21 to 5 (excellent), 3.41 to 4.2 (very good), 2.61 to 3.4 (acceptable), or less than 2.61 (not acceptable).

Table (8) showed the results of the sensory evaluation of the new jelly candy samples. The evaluators preferred the samples sweetened with stevia sugar over the samples sweetened with natural honey in all the sensory attributes tested (color, taste, flavor, and overall acceptability). The evaluation also revealed that the evaluators preferred Sample 4, which contained beetroot, pomegranate, and strawberry sweetened with stevia sugar, over all the prepared samples. The table also shows that there are significant differences at 0.05 between the prepared samples. Commercial jelly candy is poor in nutrients (Tiwari & Rastogi, 2024). However, compared to the improved jelly candy in this study, it was found more acceptable. With the currently developed jelly candy, the consumer would obtain formulas with improved nutritional and sensory properties, in addition to their low sugar content. In general, consumer acceptance of candy is affected by its consistency. The lower the consistency of the candy, the easier it is to chew and swallow.

3.7.Microbiological Analysis:

Table (9) Microbiological analysis (CFU/100gm) 10^2

Samples	Sample 1	Sample 2	Sample 3	Sample 4	Control
Total count	2	5	2	5	Nill
Coliforms	Nill	Nill	Nill	Nill	Nill
E. coli	Nill	Nill	Nill	Nill	Nill

Table (9) shows the microbial analysis of the prepared jelly candy samples compared to the commercial sample. The results showed that the total microbial count in the prepared samples did not exceed 5 cell-forming units, while all samples were free of coliform bacteria and Escherichia coli. The control sample (commercial) was free of microbial contaminants. In a study on the manufacture of fruit-based jelly sweets, the results showed that both prepared samples showed aerobic growth (1 and 1.3×102 CFU) (Teixeira-Lemos et al., 2021), which is lower than the limits permitted in European Union legislation (ICMSF, 2005) (<103 CFU). In comparison, the number of colony-forming units was observed to be lower in the jelly sweets manufactured in this study, which means that they are microbially safe for human consumption.

4.CONCLUSION

This study demonstrated the successful development of jelly candy formulated with natural, immune-boosting ingredients. The produced samples showed nutritional advantages over traditional commercial candy, particularly in their higher protein, fiber, antioxidant activity, and potassium levels. The current study provided a future vision for utilizing fruits, vegetables, and aromatic herbs with immune-boosting components such as turmeric, ginger, and black pepper in new applications of high nutritional and health value, as demonstrated by the high percentage of protein, fiber, and chemically active plant compounds in improving jelly candy samples. This jelly candy had significant potential as an attractive, health-beneficial functional food product. Overall, the findings indicated that the formulated jelly candies provide enhanced nutritional quality, valuable bioactive compounds, and favorable sensory properties, positioning them as promising functional food products. These results supported the potential for developing a functional confectionery industry based on natural ingredients rich in macro- and micronutrients and phytochemicals.

5.COMPETING INTEREST

The authors had no relevant financial information to disclose.

6,FUNDING

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