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Formula Optimization of Chewing Gum from Medicinal Herbal Extract

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Abstract: This study aimed to develop a chewing gum from a medicinal herbal extract by studying the product's physical and sensory evaluation properties. The study found that formula 3 gave good chewing gum characteristics, i.e., low hardness, not sticky, easy to chew, and high gumminess. Because of the lower hardness, gumminess, and chewiness than the other formulas and the highest springiness, the chewing jelly is sticky. Moreover, melt together at room temperature. Evaluation of sensory attributes by acceptance and overall liking of the chewing jelly found that formulas 2 and 3 had the highest liking scores for all attributes with no statistical difference ($p > 0.05$). The optimal formula for chewing gummies from medicinal herbal extract is formula 2, consisting of 7.25% gelatin, 32.63% maltodextrin, 32.63% glucose syrup, 1.75% citric acid, and 25.75% herbal extract.

Keywords: formula optimization, chewing gum, medicinal herbal extract.

中药提取物口香糖配方优化

摘要：本研究旨在通过研究该产品的物理和感官评价特性，从草药提取物中开发出一种口香糖。研究发现配方 3 赋予了良好的口香糖特性，即低硬度、不粘、易于咀嚼和高粘性。由于其硬度较低,软糖和咀嚼比其他配方和最高的弹性，咀嚼果冻是粘性的。而且，在室温下熔融在一起。通过对咀嚼果冻的接受度和整体喜好来评估感官属性，发现配方 2 和配方 3 对所有属性的喜好评分最高，没有统计学差异（$p>0.05$）。从药用草药提取物中咀嚼软糖的最佳配方是配方 2，由 7.25%明胶，32.63%麦芽糊精，32.63%葡萄糖浆，1.75%柠檬酸和 25.75%草药提取物组成.

关键词：配方优化、口香糖、草药提取物.

1. Introduction

In recent years, there has been a growing interest in the use of medicinal herbal extracts to develop chewing gums as a new way to consume natural remedies and herbal supplements in a fun and convenient form. Chewing gums have become a popular method for taking supplements and medicines because they are easy to digest, palatable, and provide controlled dosing. Adding medicinal herbal extracts to these gums allows for the combination of the therapeutic benefits of herbs

with the enjoyable experience of consuming gums. This study focuses on optimizing the formula for chewing gums using certain medicinal herbal extracts, specifically Moringa, Chaya, Mulberry leaves, Chrysanthemum, and Stevia. The goal of this study is to comprehensively understand the necessary formulation considerations, optimization techniques, and analytical methods to create high-quality and effective chewing gums with medicinal herbal extracts.

Integrating medicinal herbal extracts into chewing gum formulations has promising potential for using the health benefits of these natural ingredients [1]. Medicinal herbs have been used for centuries in traditional medicine systems across various cultures and are recognized for their therapeutic properties. By developing chewing gums with medicinal herbal extracts, it becomes possible to combine traditional remedies' knowledge with modern formulation techniques, providing consumers with a convenient and enjoyable way to incorporate herbal supplementation into their daily routines [2]. Optimizing the formula is essential in balancing the active compounds' taste, texture, stability, and bioavailability in the chewing gum formulation [3]. Selecting suitable base ingredients, sweeteners, flavors, and texturizers is crucial for achieving desirable sensory attributes [4].

In addition, statistical techniques such as mixture design or response surface methodology (RSM) can determine the optimal proportions of herbal extracts and other formulation components, ensuring an optimal blend that meets the desired sensory and therapeutic outcomes [5-6]. This article explores the formula optimization of chewing gums using medicinal herbal extracts using a systematic and scientific approach. By researching the selection and preparation of herbal extracts, formulation considerations, optimization techniques, and analytical methods, this study contributes to the development of evidence-based practices for developing high-quality chewing gums. The results will provide valuable insights into the integration of medicinal herbal extracts into chewing gums and their potential as natural remedies or herbal supplements.

2. Materials and Methods

2.1. Selection and Preparation of Medicinal Herbal Extracts

Mixed herbal formulations were prepared using dried leaves from a reputable local company. The specific leaves used in the formulations were *Morus alba L.*, *Cnidoscolus chayamansa* McVaugh, *Moringa oleifera*, and *Stevia rebaudiana* Bert. The dried leaves were ground into a fine powder using a standard laboratory blender to obtain the extracts. Subsequently, the powder was boiled in 1,000 mL of distilled water until it reached a reduced volume of approximately one-third of its original volume. The mixture was then immersed in hot water within the temperature range of 80-90°C for 15 minutes. Subsequently, the resulting extract was filtered individually using sterile Whatman grade 1 filter paper to separate the supernatant from the extraction solution. The remaining residues were stored under optimal cool conditions for future use.

2.2. Chewing Gum Preparation

The chewing gum was prepared following a standard method described by Garcia [7] with certain modifications. The composition of the chewing gum is detailed in Table 1. The preparation process involved mixing and heating glucose syrup, maltodextrin, and gelatin in a pan. A solution was prepared by dissolving gelatin powder in a warm mixed herbal extracted solution (at a temperature of 70°C). As the mixture's temperature reached 100°C, citric acid was added and thoroughly mixed. A portion of all ingredients had been added to achieve a desired Brix value of 65-75%. Subsequently, the mixture's temperature was reduced to 60-70°C to assess the impact of cooking temperatures on the final product. Before pouring the mixture into molds, any air bubbles were removed.

Table 1 Chewing gum formulation

Treatment	Ingredients (%)				
	Gelatin	Maltodextrin	Glucose syrup	Citric acid	Herbal extract
1	7.25	36.25	29.00	1.75	25.75
2	7.25	32.63	32.63	1.75	25.75
3	7.25	29.00	36.25	1.75	25.75
4	9.06	34.43	29.00	1.75	25.75
5	9.06	30.80	32.63	1.75	25.75
6	9.06	29.00	34.44	1.75	25.75
7	10.90	32.60	29.00	1.75	25.75
8	10.90	30.80	30.80	1.75	25.75
9	10.90	29.00	32.60	1.75	25.75

2.3. Functional Properties Testing

Analyzed the physical properties of the chewing gum samples and evaluated their quality and performance. A texture analyzer was used to determine the texture of chewing gum samples. The method involved subjecting the samples to controlled forces and measuring their responses to determine cohesiveness, springiness, chewiness, and gumminess. The analysis objectively measured the gum's physical texture and mouthfeel characteristics.

Evaluated utilization of product color components: Lightness (L*), Redness (a*), and Yellowness (b*) were obtained using a Hunter Lab.

The sensory evaluation was performed using consumer testing with a panel of 100 participants. The panelists evaluated the chewing gum samples using a hedonic 7-point scale for testing attributes, including color, sweetness, sourness, gumminess, hardness, chewiness, and overall liking. The panelists provided subjective ratings based on their sensory perception and preference, allowing for an assessment of the samples' sensory characteristics and overall consumer acceptance.

2.4. Statistical Analysis

The analysis of variance (ANOVA) had a significance level of 95% to assess the impact of various factors on the quality attributes of the chewing gum. ANOVA provided valuable insights into the significance of factors, including sensory and physicochemical properties. By analyzing the variation between and within groups, ANOVA contributed to a comprehensive understanding of how these variables influenced the quality attributes of chewing gums.

3. Results

Some physical properties of the chewing gum were determined, as shown in Table 2.

Table 2 Physical properties of the chewing gum

Treatments	Physical properties						
	Gumminess (N)	Chewiness (Nmm)	Cohesiveness^{ns}	Springiness (mm)^{ns}	L*	a*	b*ns
1	3,146.10^{c}	2,866.12^{c}	0.99^{ab}	0.91+0.00^{ab}	36.63+0.52^{b}	-0.18+0.11^{ef}	7.57+0.09^{cd}
2	2,660.73^{c}	2,352.76^{c}	0.97^{bc}	0.88+0.04^{ab}	40.09+1.54^{a}	-0.02+0.08^{de}	7.08+1.01^{bcd}
3	2,761.03^{c}	2,593.50^{c}	0.97^{bc}	0.94+0.05^{a}	35.92+2.83^{b}	-0.36+0.09^{f}	8.46+1.86^{bcd}
4	4,192.97^{b}	3,816.15^{b}	0.95^{cd}	0.91+0.01^{ab}	33.54+0.85^{c}	-0.64+0.25^{g}	8.58+0.50^{d}
5	4,078.20^{b}	3,684.45^{b}	1.01^{a}	0.91+0.03^{ab}	32.39+0.29^{c}	-0.33+0.02^{f}	8.38+0.42^{bcd}
6	3,034.94^{c}	2,609.12^{c}	0.97^{bc}	0.86+0.10^{ab}	32.39+0.76^{c}	0.12+0.26^{d}	8.45+0.53^{bcd}
7	5,222.88^{a}	4,409.71^{a}	0.95^{cd}	0.84+0.01^{b}	32.32+0.70^{c}	1.79+0.14^{a}	9.84+0.91^{ab}
8	4,096.33^{b}	3,751.39^{b}	0.95^{cd}	0.92+0.02^{ab}	33.09+0.86^{c}	1.17+0.11^{b}	10.66+0.22^{a}
9	4,204.49^{b}	3,307.79^{b}	0.93^{d}	0.88+0.02^{ab}	31.34+1.53^{c}	0.72+0.12^{c}	9.11+0.73^{bc}

Notes: Means (±SD) with different superscript letters in the same column (a-b) indicate significant differences ($P < 0.05$); ns indicates no significant differences among the means in the same column.

Considering experiments 1–3, 4–6, and 7–9, the gelatin content was 7.25, 9.06, and 10.90%, respectively. Increase the gummy jelly's gumminess and chewiness, and it has a more substantial structure that makes the product challenging; therefore, it requires high chewing force. The increase in trinity will also result in higher gumminess and chewiness of the gummy jelly because maltodextrin is bound to water. This resulted in increased viscosity. The liquid is difficult to move. When trapped in the gel structure, the gummy jelly has a firm texture, hard, sticky, and difficult to chew. Formula 7 contains 10.90% gelatin 32.6% and maltodextrin, having the highest gumminess and chewiness.

The results of the color measurement of products in the CIE L*a*b* system are shown in Table 2. Experiments 1–3 containing 7.25% gelatin had L* values higher than other experiments, but a* and b* values tended to increase. Experiments 4-6 contained 10.09% of gelatin and had higher a* and b* values than other experiments because of the color of the gelatin. When increasing the dosage, more gelatin will make the gummy jelly darker yellow. However, the brightness was reduced.

Results of evaluation of sensory characteristics by testing the preference of gummy jelly in various features, as shown in Table 3, showed that formulas 2 and 3 had the highest liking score for all characteristics.

Table 3 Sensory evaluation of the chewing gum

Treatment	Color	Sweetness	Sourness	Springiness	Hardness	Gumminess	Overall liking
1	5.94+1.68^{bc}	5.38+1.70^{c}	5.84+1.67^{ab}	5.47+2.05^{bc}	5.72+1.84^{abc}	5.75+2.03^{bcd}	5.94+1.81^{bc}
2	6.72+1.14^{ab}	6.38+1.43^{ab}	6.16+1.82^{ab}	6.81+1.60^{a}	6.59+1.41^{a}	6.56+1.44^{ab}	6.16+1.25^{bc}
3	6.97+1.23^{a}	6.91+1.12^{a}	6.66+1.64^{a}	6.78+1.58^{a}	6.56+1.66^{a}	6.97+1.38^{a}	6.72+1.42^{a}
4	5.78+1.45^{c}	5.75+1.37^{bc}	5.41+1.68^{b}	5.41+1.78^{bc}	5.19+1.55^{bc}	5.38+1.50^{cd}	6.06+1.27^{bc}
5	5.97+1.62^{bc}	6.25+1.39^{ab}	6.59+1.24^{a}	6.38+1.31^{ab}	6.03+1.43^{ab}	6.16+1.35^{abc}	6.31+1.31^{ab}
6	6.50+1.19^{abc}	5.84+1.74^{bc}	6.00+1.81^{ab}	5.50+1.98^{bc}	5.66+1.98^{bc}	5.72+1.84^{bcd}	5.88+1.70^{c}
7	5.91+2.02^{bc}	5.69+1.77^{bc}	5.97+1.79^{ab}	5.22+2.00^{c}	4.91+1.69^{c}	5.25+1.67^{cd}	5.56+1.74^{c}
8	6.19+1.64^{abc}	5.31+1.94^{c}	5.72+1.69^{ab}	5.34+1.84^{c}	5.00+1.81^{c}	5.16+1.63^{d}	5.53+1.59^{c}
9	6.56+1.13^{abc}	5.75+1.32^{bc}	5.75+1.76^{ab}	5.41+2.05^{bc}	5.16+1.72^{bc}	5.63+1.70^{cd}	5.81+1.53^{c}

Notes: Means (±SD) with different superscript letters in the same column (a-b) indicate significant differences ($P < 0.05$); the superscript "ns" indicates no significant differences among the means in the same column.

When considering the texture quality of these 2 formulations from table 2, it was found that the formula had the lowest hardness, chewiness, and gumminess. This shows that consumers want gummy jelly that is not too hard and easy to chew. However, formula 3 contains 7.25% gelatin, 29% maltodextrin, and 36.25%

glucose syrup. This formula has a high content of glucose syrup, making gummy jelly easily absorb moisture.

4. Discussion

In this study of gelatin content glucose syrup and maltodextrin suitable gummy jelly, there were three factors used in the study as follows: gelatin content 10-15%, glucose syrup content 40-65%, and maltodextrin content 40-60%. The experimental results are shown as follows: Table 2 shows the texture quality values of gummy jelly obtained by texture profile analysis (TPA) measurements, in which the sample is pressed twice instead of chewing. Cohesiveness is the extent to which a material has deformed before breaking. It indicates the adhesion ability of the product. The springiness value is the material's recovery rate after being pressed. It indicates the elasticity of the product. Gumminess is the force required to separate a semisolid sample until it deforms. These values were obtained from hardness X cohesiveness, and chewiness was the force used to chew. Alternatively, grinding samples until they are deformed indicates difficulty in chewing. These values were obtained from hardness X cohesiveness X springiness. Therefore, hardness, gumminess, and chewiness were used to describe the characteristics of gel-like confectionery products. The role of the gelling agent in the colloidal system is to retain sugar, water, and other ingredients, thereby affecting the structure of the gel, which results in firmness. Moreover, they have difficulty chewing [8-9].

The springiness value varies with the amount of glucose syrup. Glucose syrup contains oligosaccharides, which can increase the viscosity and stability of gummy jelly. The sugar made it into a supersaturated solution that did not crystallize or crystallize slowly, which affected the springiness of the gummy jelly. When increasing the amount of glucose syrup, gummy jelly will increase in viscosity—resulting in higher springiness. The third formulation with the highest amount of glucose syrup was the one that gave good gummy jelly characteristics, i.e., non-stickiness, easy chewing, and high flexibility, as seen from the lower hardness, gumminess, and chewiness than other formulations and the highest springiness [10].

5. Conclusion

The optimal formula for chewing gums with medicinal herbal extract is formula 2, consisting of 7.25% gelatin, 32.63% maltodextrin, 32.63% glucose syrup, 1.75% citric acid, and 25.75% herbal extract. The results will provide valuable insights into the integration of medicinal herbal extracts into chewing gums and their potential as natural remedies or herbal supplements.

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