Formulation of Dietary Supplement Chewable Gummy with Bastard Cedar Leaves (*Guazuma Ulmifolia*), Senna Leaves *(Cassia Angustifolia)* and Lime Extracts Using a Simplex Lattice Design

Muhammad Labib Qotrun Niam, Rosa Sayentina Amin, Nuri Utami, and Arifah Sri Wahyuni(✉)

Faculty of Pharmacy, Surakarta Muhammadiyah University, Central Java, Indonesia
arifah.wahyuni@ums.ac.id

Abstract. A major issue with nutrition and health is obesity. Many synthetically produced slimming medications that can have serious negative effects have been consumed by people. The purpose of this research is to determine the best formulation with the the Simplex Lattice Design (SLD) method. As a result, a solution to this problem is development of gummy products for a low-calorie diet program using natural ingredients from Bastard cedar leaves *(Guazuma ulmifolia)* as an antihyperlipidemic. Senna leaves *(Cassia Angustifolia)* contain anthraquinones, which act as laxatives and senosides in the intestines, increasing the volume of digestive products and increasing intestinal peristalsis. The test results parameters: pH, viscosity, organoleptic, weight uniformity, and texture. The following results were obtained: (a) the pH test revealed that the pH value of gummy candies was in the range of 4.26–4.57; (b) the viscosity test revealed that the viscosity value of the gummy preparations was in the range of 1–5; (c) the organoleptic examinations included color, shape, taste, smell, and texture; (d) the evaluation results of this weight uniformity test met the requirements; (e) According to the requirements, hardness subtests F1 to F7 are performed. The texture test results concluded that the addition of xanthan gum in various variations affected the hardness, gumminess and chewiness of the preparation. The SLD method was used to analyze all of the tests. The formula yielded three best solutions, the best of which was the first formulation with a desirability of 0,728.

Keywords: Obesity · Bastard cedar leaves (Guazuma ulmifolia) · Senna leaves (Cassia Angustifolia) · lime · Simplex Lattice Design (SLD) · antihyperlipidemic · weight loss

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1 Introduction

Obesity is a global nutritional health issue, affecting both developed and developing countries such as Indonesia [1]. Obesity is a global nutritional health issue, affecting both developed and developing countries such as Indonesia [1] Obesity more than doubled worldwide in 1980, according to WHO data. Adolescents with a Body Mass Index (BMI) > 2 SD increased from 4.2% in 1990 to 6.7% in 2010 and are expected to increase to 9.1% by 2025. More than 1.9 billion adults aged 18 and older were overweight in 2014, with over 600 million people worldwide obese [2]. The public has used a variety of slimming drugs made from synthetic materials that have been circulating in the market to maintain weight and prevent obesity. However, the use of slimming drugs derived from synthetic materials can result in severe side effects. Meanwhile, slimming drugs made from natural ingredients in the form of herbal preparations have become a weight loss option for the general public [3].

According to the research [4], steeping Bastard cedar leaves can boost the activity of the lipase enzyme. [5] The leaves of Bastard cedar leaves (*Guazuma ulmifolia*) have been shown to lower blood cholesterol levels in rabbits. Senna leaves *(cassia angustifolia)* is one of the ingredients that can help with constipation (Cassia angustifolia L). [6] suggested that Cassia angustifolia contains anthracenedione, which acts as a laxative to treat acute constipation. Senocide accelerates the movement of digestive products in the intestine, increasing the volume of digestive products and peristalsis in the intestinal wall. In addition to these ingredients, using lemon juice after consuming Bastard cedar leaves (*Guazuma ulmifolia*) and Senna leaves *(cassia angustifolia)* helps to stabilize body weight. Citrus (limon (L.) Burm.f.) has flavonoid compounds and phenolic groups are secondary metabolite compounds with antiobesity activity [7].

The chewable gummy formulation allows the active ingredients to be dissolved or dispersed in a soft, supple, and elastic matrix that is the basis of the gel [8]. The matrix structure allows minimal force to chew the tablet in the oral cavity, and water molecules easily penetrate into the gel structure triggering the solubilization of the active ingredient into the salivary fluid. Chewable gummy preparations of Bastard cedar leaves *(Guazuma ulmifolia)*, Senna leaves *(Cassia Angustifolia)* and lime juice have many advantages over brewed preparations, which are easy to swallow, practical to use, have an acceptable taste and aroma, as well as quick onset of [9]. The components of the chewable gummy formulation consist of gelling agent, sugar, water, sweetener, and flavor. Sweeteners and flavors are intended to mask the taste of the active ingredients and increase consumer acceptance [10]. An important component in the formulation of chewable gummy preparations is a gelling agent which functions to form a matrix structure. The type and concentration of gelling agent have a significant impact on the physical characteristics, especially the rheology and texture of the preparation [11].

Gelatin is a type of protein that can be extracted from animal bones. Gelatin has physical properties that are more chewy and reversible (when heated, it turns into a liquid, and when cooled, it turns back into a gel), can melt in the mouth, and can create thermoreversible gels. In order agar use to increase the suppleness of jelly sweets, gelatin is added during manufacturing [12]. Furthermore, according to [13], depending on the final hardness of the intended product, the amount of gelatin required to generate an acceptable gel ranges from 5 to 12%. In addition to gelatin, Xanthan gum acts as an

emulsifier and thickening in gummy manufacturing. This will have an impact on the consistency, viscosity, taste release, appearance, and water control capabilities [14]. In order to manufacture gummies with the proper formula, the research involved dosage formula optimization, particularly the quantity of Xanthan gum addition.

2 Methods

2.1 Tools and Instruments

Texture Analyzer (Brookfield AMETEK CT3–1000-115 LFRA), gummy candies mold, water bath (Memmert WNB10), rotary evaporator (BUCHI R-100), electric stove (Maspion S-301), analytical sense (Ohaus type PA 2012), glass beaker, porcelain cup, crush cup, stirring rod, semi solid pH meter (RoHS PH-009(I)A), gummy candies container, thermometer (Alco-10/150 C Limited), viscometer (Brookfield DV-II- Pro).

2.2 Materials

Bastard cedar leaves (Guazuma ulmifolia) (Klewer Market, solo, Indonesia), Senna leaves (Cassia angustifolia) (Klewer Market, solo, Indonesia), lime juice (Klewer Market, solo, Indonesia), CO_2 free aquadest (Faculty of Pharmacy UMS), Gelatin (bloom 200, China), potassium sorbate (Mupro, China), sorbitol (China), nipagin (Ueno fine chemicals industry), xanthan gum (Meihua, China), dyes (koepoe-koepoe, Indonesia) and lemon essence, citric acid (PT. Golden Sinar Sakti, Indonesia), propylene glycol (China), syrupus simplex (gulaku, Indonesia).

2.2.1 Bastard Cedar Leaves (Guazuma ulmifolia) and Senna Leaves (Cassia Angustifolia) Herbal Infusion

The infusion method is required for the extraction of Bastard cedar leaves (*Guazuma ulmifolia*) and Senna leaves *(cassia angustifolia)* because the tannin content is astringent and must be extracted with hot water or an ethanol-water mixture. Infusion is a method of extracting water-soluble active ingredients from vegetables. An infusion is a liquid preparation created by extracting vegetable simplicia with water at 90 °C for 15 min. An infusion is made by placing the ingredients in an infusion pan and adding enough water, then heating it in a water bath for 15 min, starting at 90 °C and stirring frequently. While the water is still hot, add enough to [15].

2.2.2 Lemon Juice

Lemon juice is made from fresh lemon juice that has been washed in aquades solution, cut crosswise, and squeezed with a sterile citrus squeezer. The results are accommodated in a non-microbial sterile measuring cup by adding aquades solvent (pure water).

2.2.3 Manufacturing of Gummi Candies

Gelatin, potassium sorbate, sorbitol, nipagin, xanthan gum, citric acid, propylene glycol, and aquadest are the main ingredients in the candy gummy base. Five formulas with different amounts of xanthan gum (0, 1, 2, 3, 4 g) and Syrup Symplex (60, 59, 58, 57, and 56 g) were created by dissolving gelatin and xanthan gum according to the concentration then, according to the formula's prescribed concentration, add the three active ingredients: an infusion Bastard cedar leaves (*Guazuma ulmifolia*) and Senna leaves *(cassia angustifolia)*, lime juice, potassium sorbate, sorbitol, nipagin citric acid, propylene glycol, coloring, and lemon taste Table 1. Stir until homogeneous. When the gummy candy is found, put it in the mold. Let stand for 1 h at room temperature, then put in the refrigerator for 24 h.

Table 1. Gummy candies formulation using SLD

Ingredients	**F1**	**F2**	**F3**	**F4**	**F5**	**Purpose**
Bastard cedar leaves (*Guazuma ulmifolia*)	20	20	20	20	20	Active component
Senna leaves *(cassia angustifolia)*	20	20	20	20	20	Active component
Lemon juice	20	20	20	20	20	Active component
Gelatin	35	35	35	35	35	Filling material
Potassium Sorbate	0,05	0,05	0,05	0,05	0,05	Preservative compounds
Sorbitol	13	13	13	13	13	Non-synthetic sugar flavor
Nipagin	0,05	0,05	0,05	0,05	0,05	Preservative compounds
Gum Xanthan	0	1	2	3	4	Binder
Lemon essence	0,3	0,3	0,3	0,3	0,3	Natural dyes formulated
Lemon dye	0,5	0,5	0,5	0,5	0,5	Prepared flavor from nature
Acid Sitrid	0,5	0,5	0,5	0,5	0,5	Preservative compounds
Simplex syrup	60	59	58	57	56	Sweeteners and coating agents
Propylene glycol	5	5	5	5	5	Binder
Total	**174,4**	**174,4**	**174,4**	**174,4**	**174,4**	

Information:
Preparation F1: A formula containing 0 g of xanthan gum and 60 g of simplex syrup.
F2 preparation: A formula containing 1 g of xanthan gum and 59 g of simplex syrup.
F3 preparation: A formula containing 2 g of xanthan gum and 58 g of simplex syrup.
Preparation F4: A formula containing 3 g of xanthan gum and 57 g of simplex syrup.
F5 preparation: A formula containing 4 g of xanthan gum and 56 g of simplex syrup.

2.3 Gummy Candies Formulation

The manufacture of gunna gummy preparations refers to previous research, according to the modified forms gelatin and Xanthan gum that were employed [16]. Pectin was not employed in the preparation because it had no discernible impact on the gummy's flexibility, and instead, gelatin was developed. The formulation was changed to Xanthan gum to calculate the control value of the product since Xanthan gum was utilized in this study to test the gummy's flexibility. Non-fructose simplex syrup was utilized in this investigation because it is safely edible. The sweetness of the product to be marketed can be decided by altering the formulation used in this study.

The ingredients were divided among the containers after being weighed using an analytical balance (mg). A 250 mL beaker glass was filled with all the ingredients and cooked on an electric cooktop (Solution A). Gelatin and xanthan gum (Solution B), which were used as binders, were weighed following the formulation and added to a porcelain dish while waiting for (Solution A) to boil at 90 °C, as determined by a digital thermometer. When it reaches a boil, add the gelatin and stir with a stir bar before adding the xanthan gum by the recipe as written. Once combined, allow the gummy to soften for ten minutes before testing its viscosity (thickness) with a viscometer and its pH level with a pH meter to determine its pH level.

2.4 Statistical Analysis

Statistical analysis was performed with SPSS (IBM Corporation, New York, NY, USA). One-Way ANOVA was used to distinguish the characteristics of the resulting preparations, then statistical tests were carried out to see the effect of differences in gelatin concentration on the test results parameters pH, viscosity, organoleptic, weight uniformity and texture. The results were significant when $p < 0.05$.

3 Gummy Candies Evaluation

3.1 Acid-Base Level Test (pH)

The pH determination test was carried out by dipping the pH meter into the gel mass from the gummy candies preparation just before the formula was removed from the water bath and poured into the mold. The pH value of the preparation is measured by looking at the pH value listed on the pH meter. The pH used is pH so that the product is durable in storage because it is acidic.

3.2 Viscosity Test (Thickness)

A viscosity test is carried out to determine the level of viscosity of the resulting preparation using a Brookfield RVF 100 viscometer. Viscosity is a statement of the liquid to flow in unit time, the higher the viscosity the more difficult it is to flow or the greater the resistance [17]. Theoretically, the product made has a low to high viscosity difference due to the different effects of xanthan gum and syrups simplex.

3.3 Organoleptic Test (Hedonic Test)

The hedonic test involves having panelists respond by indicating whether or not they have consumed the product [18]. Evaluation of the ingredients is, including: 1. Color; 2. Scent; and 3. Flavor; 4. Form; 5. Texture. Twenty male and female respondents between the ages of 19 and 23 took the test. Males and females who were 19 to 23 years old and Muhammadiyah University of Surakarta students majoring in pharmaceuticals were the inclusion criteria. Strongly despise (1), dislike (2), slightly dislike (3), normal (4), somewhat like (5), and like (6) are the numerical values used in the hedonic test (7).

3.4 Test for Weight Uniformity

20 gummy candies were weighed individually for the weight uniformity test, and the average weight and weight deviation of each candy were then determined. The percent coefficient of variation stated for each formula, namely formulas 1–5, complies with the Indonesian Pharmacopoeia V's standards for the percent coefficient of variation in weight uniformity, which is 5%.

3.5 Analysis of Texture Profiles (TPA)

The texture characteristics of the preparation were evaluated using the texture analyzer model T.A Plus Texture Analyzer. One gummy was taken from each formula by random sampling and then measured using a texture analyzer. Measurements were made using different probes for texture profile analysis, which included hardness and gumminess, as well as product softness. The results of the measurements will be obtained in the form of numerical values with units of hardness (hardness) being force Kg, (e.g., distance mm), and softness (N). Reviewed through an organoleptic test (hedonistic test: product preference).

4 Results

4.1 Test for Acid-Base Level (pH)

The results of the pH test indicated that the gummy had a pH value between 4,26–4,57. Then, using SPSS software, the entire data from the pH test results was examined. The data were found to be regularly distributed and homogeneous (*p-value $>$ 0.05) by the normality and homogeneity tests. Additionally, one-way ANOVA was used to perform a parametric analysis. At the 95% threshold of significance, the p-value was *0.032 $>$ 0.05, Indicating that there was no significant difference between F1 and F8. This is so that the pH value, which is dictated by the active chemicals at the same concentration, such **as** citric acid and potassium sorbate, can be accurately measured. The optimum pH conditions for gel formulation are close to pH 3.2 or at an acidic pH [19]. This indicates that the research results have been optimal (Figs. 1 and 2).

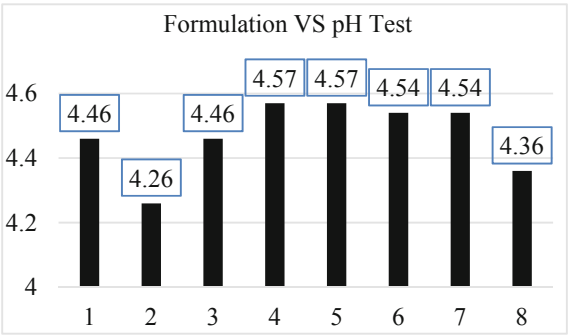

Fig. 1. The results of a pH test conducted on gummy candies that were infused with Bastard cedar leaves (Guazuma ulmifolia) and Senna leaves (cassia angustifolia)

4.2 Viscosity Test (Viscosity of Water)

Water is an important component of foods that can affect their appearance, texture, and taste. The water content of foods determines their freshness and durability. because water content has a strong influence on food quality, Water is frequently removed or reduced during processing [20].

A viscosity test revealed that the viscosity of gummy candies ranged from 1 to 5. The viscosity is the amount of fluid that flows per unit of time. The higher the viscosity, the more difficult or resistant the substance is to flow. The T-test results showed that formulations 1–5 were very significantly different, so no further Annova analysis was required. It is possible to conclude that the best formulation is formula 1 with the lowest viscosity test value, as the product is not too runny and thick, and it is very durable in material storage. According to research [14], a high Xanthan gum concentration impacts the value of increased viscosity, and the preparation's temperature also affects the viscosity. In contrast to formula 5, which demonstrates that this can also happen as a result of an increase in temperature, this study illustrates the results in accordance with

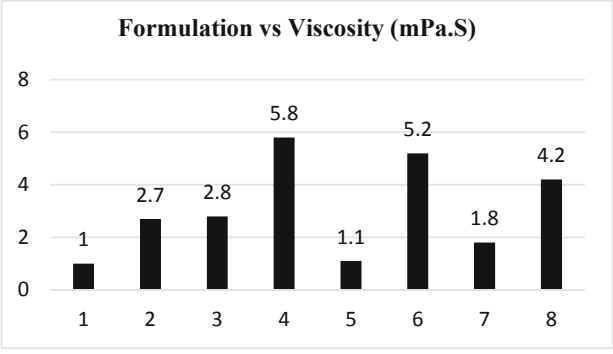

Fig. 2. Viscosity test results of Gummy candies infusion of Bastard cedar leaves (Guazuma ulmifolia) and Senna leaves (cassia angustifolia)

the notion that for formulas 1–4, there is an increase in linear viscosity with an increase in Xanthan gum concentration.

4.3 Organoleptic Test (Hedonic Test: Likes)

Organoleptic examinations carried out included color, shape, taste, smell and texture. Gummy Candies infusion of Bastard cedar leaves (*Guazuma ulmifolia*) and Senna leaves *(cassia angustifolia)* can be seen in Fig. 1 and the results of the organoleptic test of gummy Candies can be seen Table 2 (Fig. 3).

The organoleptic test on color showed a difference caused by the amount of liquid infusion bastard cedar leaves (Guazuma ulmifolia) and Senna leaves (Cassia angustifolia) that was added, causing the color of the gummy candies to be brownish yellow because the yellow dye from the lemon was not able to cover the color of the infusion. The shape of the gummy candies produced from each formula corresponds to the mold used, namely the form of a rose, because the preparation of gummy candies is aimed at teenagers and adult so that it is made as attractive as possible.

Although the gummy candies are scented with lemon following the essence used lemon essence the flavor is still somewhat unpleasant. Because the potassium sorbate, citric acid, and lemon essence are employed in the same manner in each formula, the end result has the same flavor. The sole independent variable that is altered to mask the

Table 2. Extract organoleptic test bastard cedar leaves and Senna leaves

Organoleptic	F1	F2	F3	F 4	F 5	F6	F7	F8
Colour	Orange	Orange	Orange	Orange	Orange	Orange	Orange	Orange
Aroma	Weak Lemon	Weak Lemon	Weak Lemon	Weak Lemon	Weak Lemon	Weak Lemon	Weak Lemon	Weak Lemon
Flavour	Sweet Slightly Sour	Sweet Slightly Sour	Sweet Slightly Sour	Sweet Slightly Sour	Sweet Slightly Sour	Sweet Slightly Sour	Sweet Slightly Sour	Manis Sedikit Asam
Shape	Gummy Rose	Gummy Rose	Gummy Rose	Gummy Rose	Gummy Rose	Gummy Rose	Gummy Rose	*Gummy Rose*
Texture	Slightly Chewy	Chewy Enough	Chewy	Very Chewy	Very Chewy	Slightly Chewy	Chewy Enough	Very Chewy

Fig. 3. Gummy candies bastard cedar leaves and Senna leaves. *Note* (A) = Formula 1, (B) = Formula 2, (C) = Formula 3, (D) = Formula 4, (E) = Formula 5

bitter flavors of the three active substances is the addition of syrupus simplex. The bitter taste of gummy candies is produced by the lemon flavor's inability to mask the bitter taste of the leaves of bastard cedar leaves and Senna leaves. The gummy sweets have a 20 mL infusion inside of them.

In the organoleptic test of the shape and texture, there are differences in each formula. The addition of the amount of gelatin used causes the elasticity of the gummy candies to increase. In line with research by [21], which states that the lower the gelatin concentration, the softer the jelly candy produced. Meanwhile, the higher the concentration of gelatin, the resulting jelly candy is rather hard and less elastic.The best formulation is the F1 formula with the author's level of preference for color, aroma, taste, shape, texture, and significance value of 0.001–0.000, therefore ($p < 0.005$) at the 95% significance level, it means that there is no significant or significant difference in formula 1.

4.4 Weight Uniformity Test

One of the production requirements that must be addressed is weight uniformity. The number of variations between the weight of each sweet and the total weight was used to calculate the weight uniformity. The study of the weight uniformity test revealed no differences between the five formulae. The Indonesian Pharmacopeia states that when sweets are weighed one at a time, there should be no more than two whose weights differ from the average weight by more than 5% each and no more than three whose weight differences are greater than 10% [20] (Table 3)

4.5 Texture Profile Analysis (TPA) Test

See Table 4.

4.5.1 Hardness

The maximum force required to compress a sample to a specific thickness is defined as hardness. The physical hardness of the gummy candies was measured and found to

Table 3. Homogeneity test observation results

Formulation	Average weight g ± SD	Partition coefficient (CV)
F1	7,530 ± 0,237	0,03
F2	7,367 ± 0,304	0,01
F3	7,176 ± 0,104	0,03
F4	7,800 ± 0,104	0,02
F5	7,370 ± 0,171	0,02
F6	7,542 ± 0,219	0,2
F7	7,430 ± 0,277	0,04
F8	7,302 ± 1,527	0,02

Table 4. Texture profile analysis (TPA) test results

Formulasi	Hardness (N)	Gumminess (N)	Chewiness (N)
F1	41,28	39,16	38,25
F2	73,76	69,55	68,45
F3	69,2	62,57	62
F4	95,44	90,62	89,08
F5	131,64	118,81	81,02
F6	84,86	82,62	117
F7	50,7	48,14	46,87
F8	182,18	113,37	110,78

be between 41.28 and 182.18 N Table 2. This data shows that the harder the product is, the higher the concentration of the xanthan gum mixture in the gummy candies. The lowest hardness, 0 g of 41.28 n, was obtained without the use of xanthan gum, and the highest, 4g of 182.18 N, was obtained with the use of xanthan gum. According to [22], the maximum required hardness value for gummy jelly is 131.5N, so hardness test results that do not meet this requirement are rejected.

4.5.2 Gumminess

Gumminess is one of the parameters that can be used to determine the quality of consumer-acceptable gummy candies. Elasticity is a rheological property of plastic food products that allows them to resist breakage caused by compressive forces that can deform or deform. Consumers' ability to consume gummy candies with good elasticity will be assessed. According to this data, the higher the concentration of the xanthan gum mixture in the gummy candies, the greater the elasticity of the product. The product with no xanthan gum had the lowest elasticity of 39.16 N, while the product with xanthan gum had the highest elasticity of 118.18 N at 5 g. According to the respondent's approval, formula 1 gumminess value of 39.16 N is chosen for determining the ideal gumminess value.

4.5.3 Chewiness

Tenderness is the most difficult texture characteristic to precisely measure because it involves compressing, shearing, piercing, grinding, tearing, and cutting at a given body temperature, as well as saliva lubrication. The measurement of the softness of the physical properties of gummy candies yielded values ranging from 38.25 to 110.78 n Table 2. This data shows that increasing or decreasing the amount of xanthan gum in gummy candies does not guarantee softness. The lowest softness was obtained without the use of xanthan gum at 38.25 N and the highest at 2 g of xanthan gum at 117 N, implying that xanthan gum does not affect on chewiness. According to the respondent's approval,

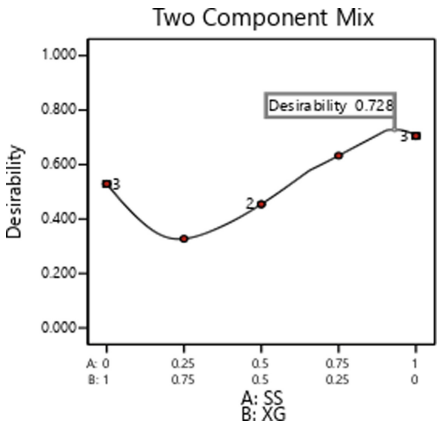

Fig. 4. Selected optimum gel formula from countour plot

formula 1 chewiness value of 38.25 N is chosen for determining the ideal chewiness value.

4.6 Simplex Lattice Design (SLD)

Optimization of the dosage formula using the Design Expert version 13 software program with the Mixture Simplex Lattice method. Counter plots can be generated by entering the response value of each formula and the ideal response value of each physical property of the preparations from the test results of pH, viscosity, organoleptic, weight uniformity and texture obtained from the literature. Based on the literature, the ideal response value for pH is acidic because it is influenced by the material, the lowest viscosity test value is preferred so that the product is not too runny and thick which makes the storage of the material durable. The organoleptic results were obtained from the hedonic test with the highest value indicating the preference. The weight uniformity with the lowest SD shows the best weight uniformity. Texture value is influenced by the addition of xhantan gum with a low hardness value, high elasticity and softness are preferred.

The Design Expert version 13 program will select a formula that is considered to have the highest desirability so that the selected optimum formula will produce the desired physical properties of the gel. A good desirability value is close to 1, which is 0.728. The counterplot is shown in Fig. 4 Based on the Countour plot in the figure, the optimum point is obtained which is marked by a box labeled Prediction accompanied by the given desirability value, namely 1. The optimum formula point indicates that the physical properties of the preparation are close to ideal, is formula I with addition of xanthan gum 0.

4.7 Nutrition Analysis

Nutritional analysis is used to determine the content of gummy candy including total calories, total fat, moisture content, carbohydrate, protein, sodium content, total sugar

Table 5. Nutrion fact gummy candy liquid infusion bastard cedar leaves and Senna leaves

Nutrition facts	Value
Total calories	271.27 kcal/100 g
Total fat	0.43%
Moisture content	32.16%
Carbohydrate	44.30%
Protein content	22.55%
Natrium	55.01 mg / 100 g
Total sugar	1.36%
Ash content	0.26%

Table 6. Gummy quality requirements

Criteria	Requirements	
Taste		Normal
Smell		Normal
Moisture content	% Fraksi Massa	Max 20
Ash content	% Fraksi Massa	Max 3

and ash content, this will provide information on the feasibility of gummy candy to be consumed for obese people (Table 5).

Referring to the gummy quality requirements from the following national standardization SNI 3547–2-2008, it shows that the results of this study have met the standard gummy criteria [23] (Table 6).

5 Conclusion

The optimum formula point shows that it gives the physical properties of the preparation that are close to the ideal test based on testing parameters pH, visibility, organoleptic, weight uniformity, and texture is formula I with the addition of 0 xanthan gum and a desirability value of 0.728.

References

1. Kemenkes RI, "Hasil Riset Kesehatan Dasar Tahun 2018," *Kementrian Kesehat. RI*, vol. 53, no. 9, pp. 1689–1699, 2018.
2. Nuraini, Anis, Murbawani, Etisa, and Di, "Hubungan Antara Ketebalan Lemak Abdominal Dan Kadar Serum High Sensitivity C-Reactive Protein (Hs-Crp) Pada Remaja," *J. Nutr. Coll.*, vol. 8, no. 2, p. 81, 2019.

3. Katno and S. Pramono, "Back to nature," *Crafts*, no. 226, pp. 51–55, 2010.
4. Joshita, Azizahwati, and Wahyuditomo, "Pengaruh Daun Jati Belanda Terhadap Kerja Enzim Lipase Secara In Vitro," *War. Tumbuh. Obat Indones.*, vol. 6, no. 3, pp. 6–8, 2000.
5. Monica and Farida, "Karakteristik Fisik Dan Kimia Permen Jelly Caulerpa sp. Physical and Chemical Characteristic of Caulerpa sp. Jelly Candy," War. Tumbuh. Obat Indones., vol. 6, no. 3, pp. 12–13, 2000.
6. Chien *et al.*, "Anthracenedone Compounds," *United States Pat. Appl. Publ.*, vol. 2, no. 12, 2010.
7. Ezz *et al.*, "Protective and Curative Antiobesity Potential of Lemon Peel Extract in Rats Fed on High Fat Diet: Mechanism of Action," *Int. J. Biochem. Res. Rev.*, vol. 12, no. 4, pp. 1–17, 2016.
8. Matulyte, Inga, Marksa, Mindaugas, Bernatoniene, and Jurga, "Development of innovative chewable gel tablets containing nutmeg essential oil microcapsules and their physical properties evaluation," *Pharmaceutics*, vol. 13, no. 6, 2021.
9. Jadhav and Mohite, "A Comprehensive Review On: Medicated Chewing Gum," J. Curr. Pharma Res., vol. 4, no. 3, pp. 1215–1224, 2014.
10. Carbonell and Marisol, "NSUWorks Likability and Efficacy of Gummy Oral Sedative by Pediatric Patients Likability and Efficacy of Gummy Oral Sedative by Pediatric Patients," no. 76, 2019.
11. D. Pizzoni, D. Compagnone, C. Di Natale, N. D'Alessandro, and P. Pittia, "Evaluation of aroma release of gummy candies added with strawberry flavours by gas-chromatography/mass-spectrometry and gas sensors arrays," *J. Food Eng.*, vol. 167, pp. 77–86, 2015.
12. Amaria, Feby, Egita, Luliana, and Sri, "Formulasi Sediaan Gummy Candies Ekstrak Herba Pegagan (Centella asiatica) menggunakan pektin dari Daun Cincau Hijau (Cyclea barbata Miers) Gummy Candies formulation of Pegagan Herba Extract (Centella asiatica) using pectin from Green Cincau Leaves (," *J. Mhs. Farm. Fak. Kedokt. UNTAN*, vol. 5, no. 1, 2016.
13. Koswara and Sutrisno, "Teknologi pembuatan permen," 2009.
14. Lopes *et al.*, "Xanthan gum: Properties, production conditions, quality and economic perspective," *J. Food Nutr. Res.*, vol. 54, no. 3, pp. 185–194, 2015.
15. Departemen Kesehatan Republik Indonesia, *Farmakope Indonesia*, IV. Jakarta, 1995.
16. Andriani, Elliya, Luliana, Sri, Anastasia, and Desy, "Formulasi Sediaan Gummy Candies Ekstrak Herba Meniran (Phyllanthus Niruri Linn) Gummy Candies Of Meniran (Phyllanthus Niruri Linn) Extract Formulation," *J. Mhs. Farm. Fak. Kedokt. UNTAN*, vol. Vol 5, no. 1, pp. 1–11, 2021.
17. Putra A. S, *Disain dan Komputerisasi Viskometer Kapiler*. Jember: Universitas Jember, 2013.
18. Anief, *Ilmu Meracik Obat*. Jogjakarta: UGM Press, 2010.
19. Hasniarti, "Studi Pembuatan Dodol Buah Dengen (Dillenia serrata Thunb)," *Univ. Hasanuddin*, pp. 1–66, 2012.
20. Winarno, *Kimia Pangan dan Gizi*. Jakarta: Gramedia Pustaka Utama, 2004.
21. Lewerissa and V. Janihers, "Karakteristik Fisik Dan Kimia Permen Jelly Caulerpa Sp.," *Skripsi Strat. 1*, no. November, pp. 3–7, 2017.
22. Subaryono, Subaryono, Utomo, and B. S. Bandol, "Penggunaan Campuran Karaginan dan Konjak dalam Pembuatan Permen Jelli," *J. Pascapanen dan Bioteknol. Kelaut. dan Perikan.*, vol. 1, no. 1, p. 19, 2006, doi: https://doi.org/10.15578/jpbkp.v1i1.227.
23. Komite Teknis Perumusan SNI, "Badan Standarisasi Nasional Indonesia." http://sispk.bsn.go.id/PanitiaTeknis/DetilPantek/107