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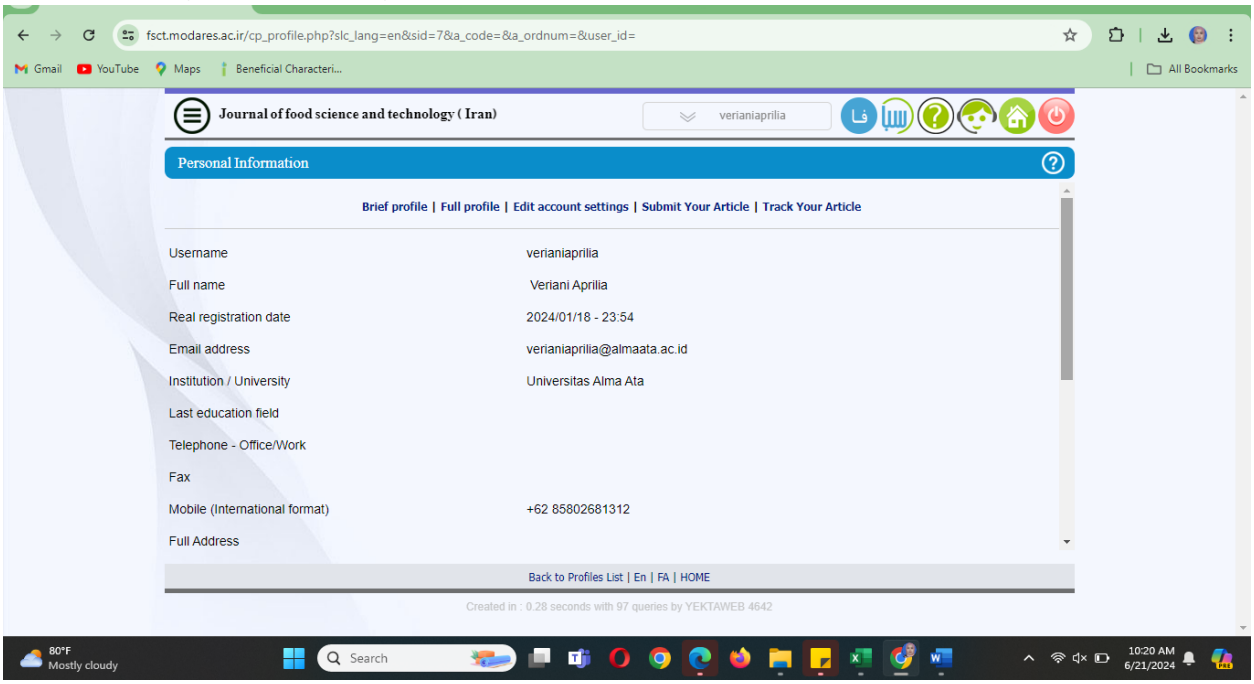

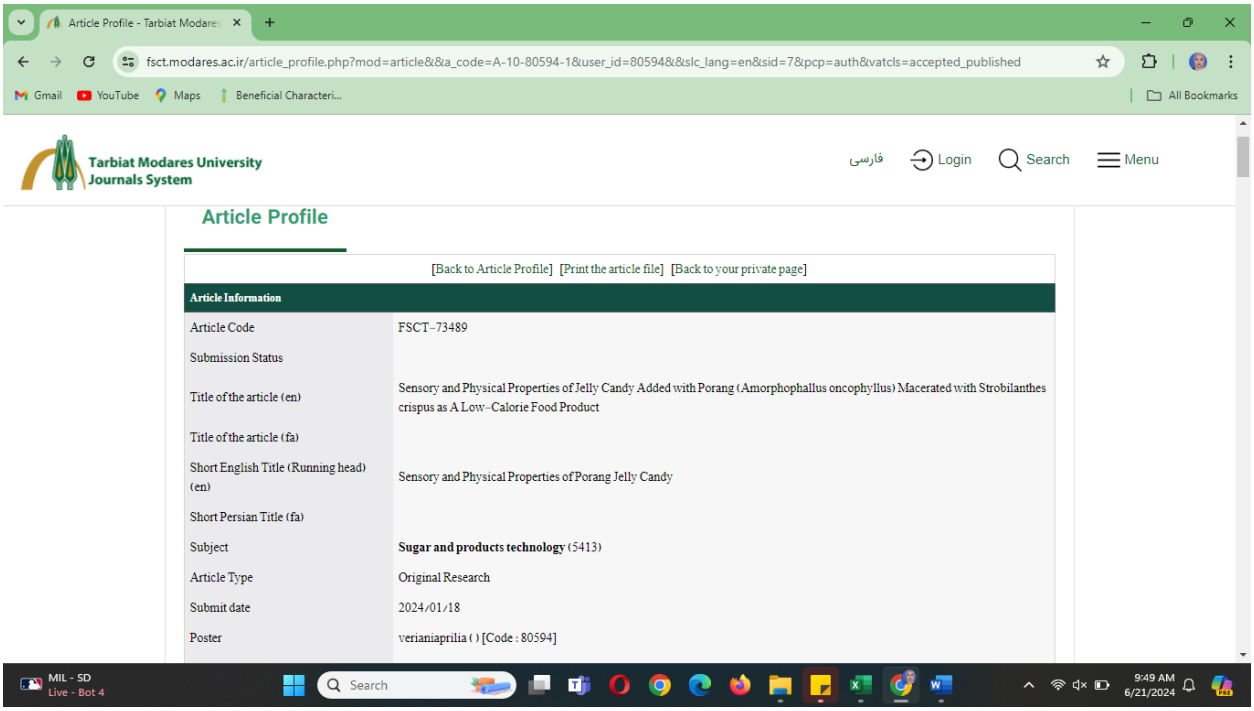
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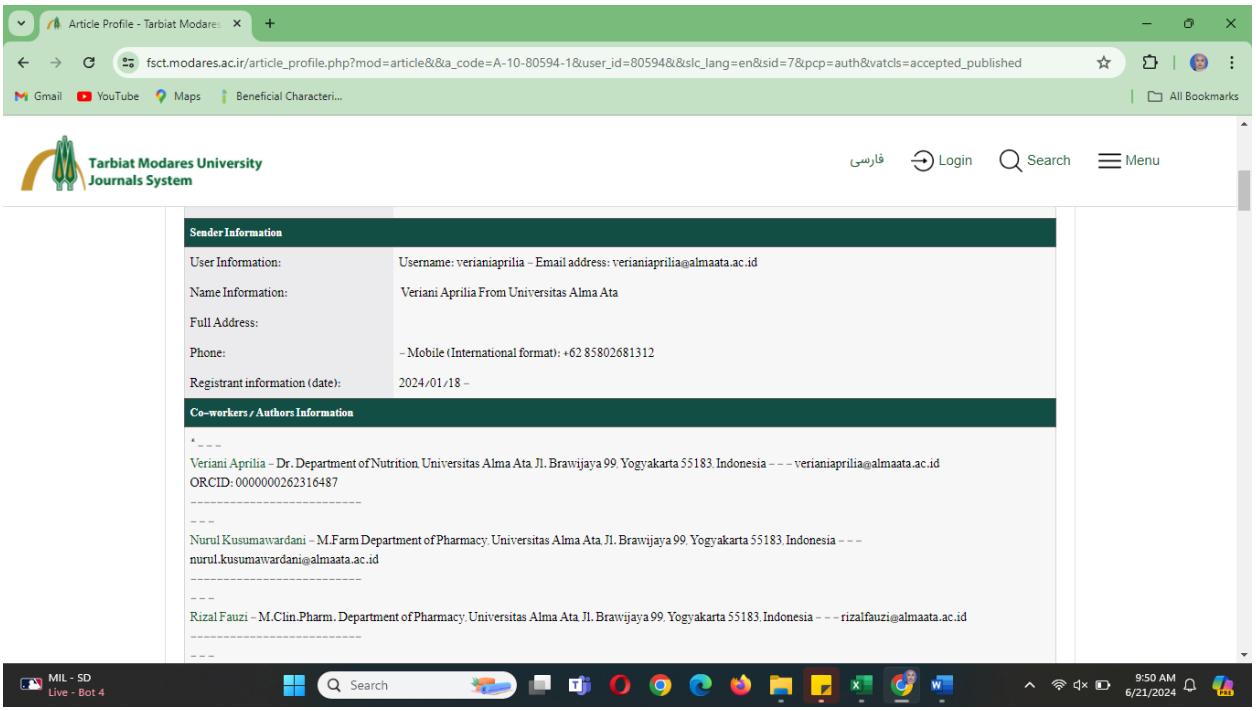
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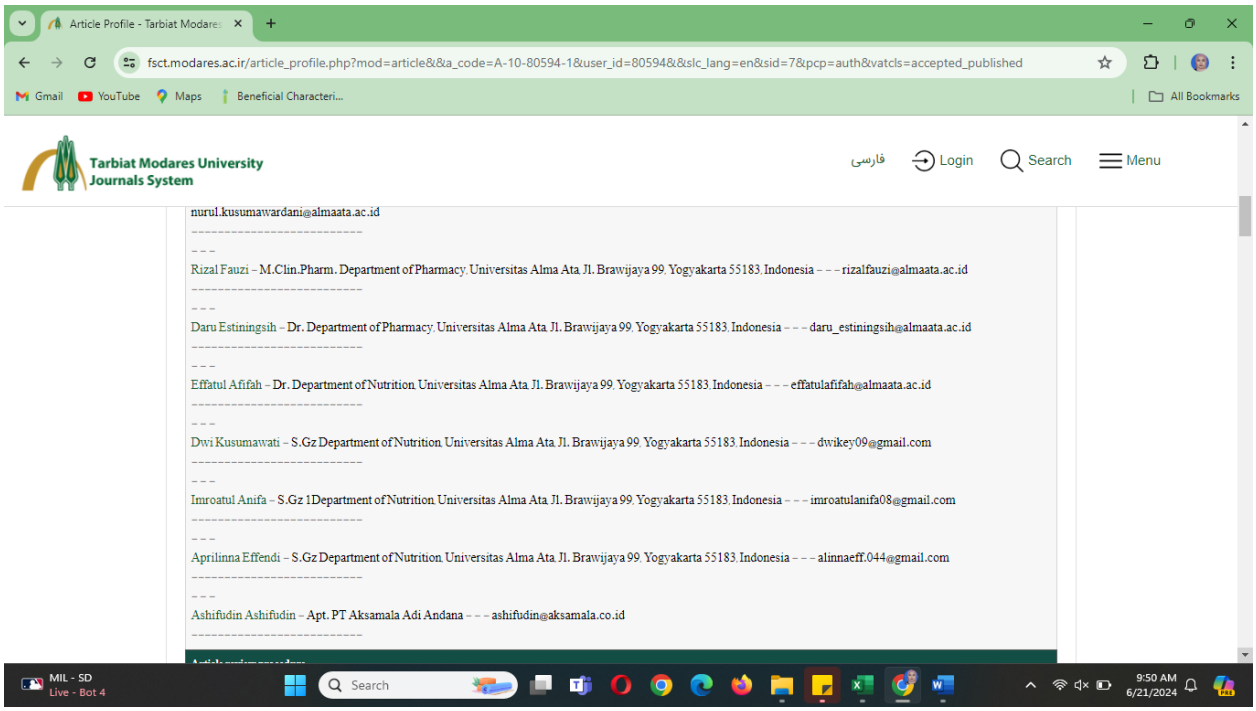
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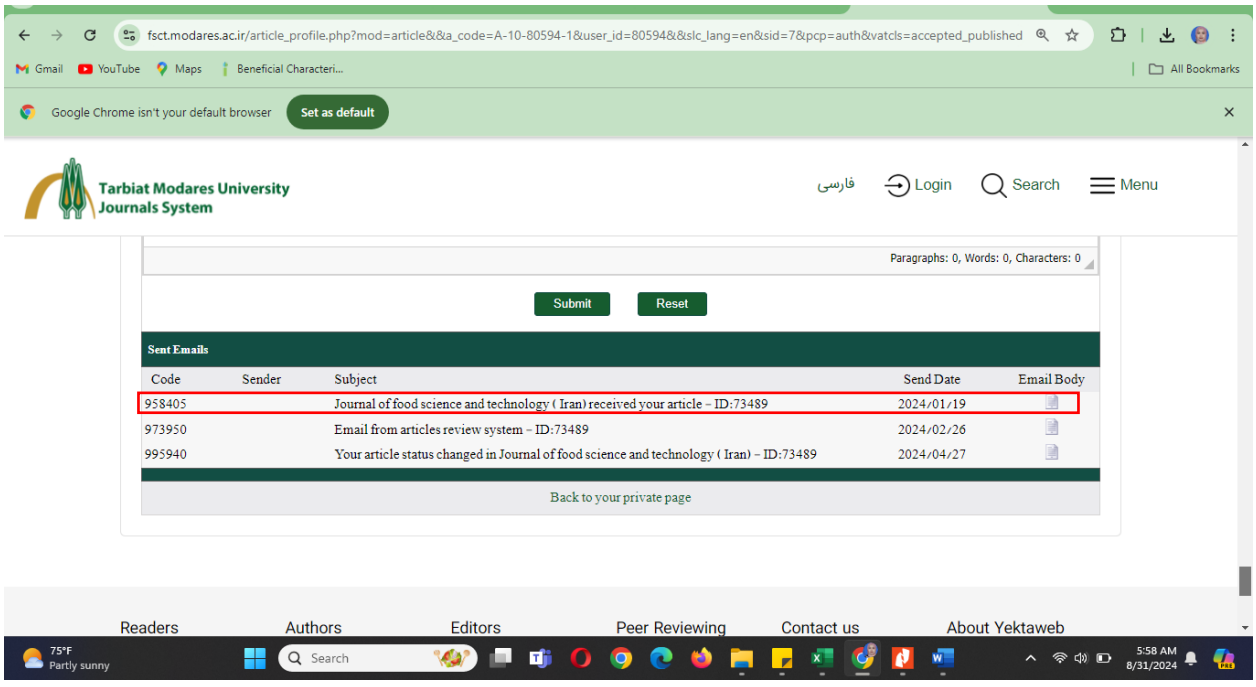
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Sensory and Physical Properties of Jelly Candy Added with Porang (*Amorphophallus oncophyllus*) Macerated with *Strobilanthes crispus* as A Low-Sugar Food Product

ABSTRACT

Porang (*Amorphophallus oncophyllus*) is a local food source that may be developed to address food security concern. Diversification in processing should be done to increase its consumption. Jelly candy with porang added that has been macerated with *Strobilanthes crispus* (PMS) was developed to be a low-sugar food product with functional antihyperglycemic properties. This study aimed to evaluate the sensory and physical properties of this jelly candy, including its color and texture. Jelly candy was made from carrageenan, jelly flour, gelatin, dragon fruit, corn sugar, citric acid, strawberry flavor. The treatment was the amount of PMS, namely: 0.2, 0.5, 0.7, 0.9%. The sensory evaluation was carried out using hedonic scale, while colour and texture profile properties were each analyzed using a chromameter and texture analyzer. The sensory evaluation results showed that PMS added in a concentration of 0.7% was preferred for the texture and the taste. For the color properties, an increase in PMS resulted in an increase in the L value (lightness) (with a range of 17.53-20.64), but a decrease in a value (red-green component) (with a range of 3.85-6.27). However, this did not affect the b value (yellow-blue components) (with a range of 4.54-4.88). For the texture profiles, increasing the PMS caused a decrease in the hardness bite 1, gumminess, fracture, and chewiness, but an increase in cohesiveness. It did not affect the adhesiveness and springiness. This study found that PMS concentration in jelly candy affected the preferences of texture and taste and also the physical properties of L and a value. For the texture profiles, it affected the hardness bite 1, gumminess, fracture, chewiness, and cohesiveness.

Keywords: porang, Strobilanthes crispus, texture, color, sensory

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1-INTRODUCTION

Food security relates to fulfilling a person's food and ensuring it is of sufficient quantity and quality, while also ensuring it is safe, diverse, nutritious, equitable, and affordable so that one can live a healthy and productive life [1]. Food security can be indicated by the number of nutritional problems in a country. According to UNICEF data, the prevalence of malnutrition, calculated from the number of stunting cases, reached 22.3% in 2022. This prevalence has decreased since 2020, but the decline is gentle at around 0.2-0.3% per year. On the other hand, between 2005 and 2022, the problem of overnutrition has not decreased, constantly at the number of 5.5%[2]. Based on this phenomenon, food security is still a global problem. Apart from insufficient food sources leading to malnutrition, welfare inequality also led to overnutrition in certain populations.

The prevalence of overnutrition is not as high as the prevalence of undernutrition, but this problem has not decreased from year to year. Handling overnutrition status is important because of its risks to the occurrence of metabolic diseases, such as diabetes mellitus (DM). This disease is still the cause of death in the world [3]. Those with DM can treat this disease using chemical or herbal methods. Maintaining a dietary pattern is also a must for DM patients to control blood sugar level.

Staple foods and snacks for people with DM have been developed, and foods with low-glycemic index properties are especially good for this population. Porang (*Amorphophallus oncophyllus*) is a tuber with a low glycemic index that contains the bioactive substance glucomannan, which has been proven to reduce blood glucose level [4]. Glucomannan has been widely diversified for the sake of consumers' enjoyment. However, when glucomannan is in the form of porang flour, it is more affordable. Despite this, the calcium oxalate content of porang flour is worth consideration, as it poses a risk for the development of a kidney disorder [5].

A porang flour with a lower calcium oxalate content was developed by macerating porang flour with an ethanolic extract of *Strobilanthes crispus*. The ability of this flour to lower blood glucose levels has been proven preclinically [4] and a toxicity study has also been conducted on it [6]. It is important for this flour to be used in the production of food products so that it is easier to consume it daily. The development of jelly candy that had porang macerated with *Strobilanthes crispus* (PMS) added to them was carried out as a snack food that was expected to control blood glucose levels. This study aimed to evaluate the sensory and physical properties of this jelly candy, including its color and texture.

2. MATERIALS AND METHODS

2.1. Materials

Porang was obtained from the Porang Nusantara Activist Association branch of Boyolali, North Java, Indonesia. The PMS was then produced based on an Indonesian submission patent (no S00202006668) [7].

2.2. Production of jelly candy with PMS added

The jelly candy was made from carrageenan, jelly flour, gelatin, dragon fruit, corn sugar, citric acid, strawberry flavor. Its composition was based on an Indonesia submission patent (no S00202211830) [8]. The materials were mixed, cooked, and molded [9]. The PMS was added in different concentration (0.2, 0.5, 0.7, 0.9% for F1, F2, F3, and F4, respectively).

2.3. Sensory analysis

The preferences of jelly candy were analyzed by hedonic test using 30 semi-trained panelists. The inclusion criteria of panelists were had passed the sensory lesson, healthy, not drinking, not smoking, and willing to be a panelist. The panelists were asked to eat the samples and write their preferences of color, taste, flavor, texture, and overall [10]. A five hedonic scale was used with 1 (extremely dislike), 2 (dislike), 3 (slightly like), 4 (like), 5 (extremely like).

2.4. Color measurement

The colors of jelly were expressed in three dimensions: lightness L*, redness a*, and yellowness b*. These colors were measured by using a chromameter CR-400 (Konica Minolta Business Technologies, Inc., Tokyo, Japan). The chromameter was adjusted for illuminant C. It was then standardized using a white reflector plate. the color of jelly was measured by using the base material color measurement apparatus.

2.5. Texture profile analysis

A texture profile analysis was performed as hardness bite 1, gumminess, fracture, chewiness, cohesiveness, adhesiveness, and springiness index. These elements were analyzed using a CT3 texture analyzer (Brookfield Engineering Laboratories, Inc., USA).

2.6. Statistical analysis

Software called SPSS 16.0 was utilized for statistical analysis. A one-way analysis of variance (ANOVA) was used to analyze the data. Duncan's multiple range test (DMRT) was used to compare means at $p<0.05$.

3. RESULTS AND DISCUSSION

3.1. Sensory properties

Thirty panelists scored the sensory attributes based on the preference or acceptance of color, flavor, taste,

texture, and overall. The preference scores were above 3 in all sensory attributes which means jelly was slightly liked. Table 1 shows that the addition distinctive concentration of PMS did not affect the color, flavor, and overall preferences of jelly candy ($p>0.05$). However, the texture and taste were affected ($p<0.05$) by the addition of PMS. The highest scores of preferences for taste and texture were observed in F3 samples. The taste attribute was mainly influenced by the inclusion of dragon fruit, while the texture was affected by the combination of polysaccharides of gelatine, glucomannan in PMS, and carrageenan [11]. This sensory information is needed in the food industry to describe the acceptability of consumers [10].

Table 1. Sensory properties of jelly candy in different concentration of porang macerated with *Strobilanthes crispus*

Sensory Attributes	F1	F2	F3	F4
Color	3.90±0.71^{a}	3.87±0.63^{a}	3.70±0.70^{a}	3.57±0.82^{a}
Flavor	3.43±0.77^{a}	3.60±0.72^{a}	3.53±0.94^{a}	3.20±0.89^{a}
Taste	3.40±0.77^{ab}	3.40±0.81^{ab}	3.73±0.83^{b}	3.13±0.97^{a}
Texture	3.23±0.63^{a}	3.53±0.94^{ab}	3.73±0.87^{b}	3.20±0.89^{a}
Overall	3.33±0.66^{a}	3.57±0.77^{a}	3.70±0.75^{a}	3.33±0.99^{a}

Notes: F1, F2, F3, and F4 were the jelly candy with the concentration of 0.2, 0.5, 0.7, 0.9%, respectively. Means with distinctive letters within the same row are significantly different ($p<0.05$).

3.2. Color properties

Based on Figure 1, the lightness (L*) values of jelly candy were in the range of 17.53–20.64, which indicated white. The L* values tended to increase with the addition of up to 0.7% PMS (F3) ($p < 0.05$), except for F2. This indicates that the addition of PMS increased the brightness of the candy. The jelly candy used in this study had a dark purple coloration due to the addition of a natural colorant from dragon fruit. Theoretically, there were also yellow carotene and polyphenols in the PMS that were susceptible to oxidation, which resulted in a brown color [12][13][14].

The a* values that were in the range of 3.85–6.27 indicated the red colors of jelly (Figure 1). There was a decrease in redness as more porang was added ($p < 0.05$). The red color in the jelly candy came from the betacyanin pigment of the dragon fruit [15]. The addition of PMS reduced the concentration of betacyanin in the candy, thus reducing redness.

120 The b* values of the candy were in the range of 4.54–4.88 (Figure 1). The addition of PMS resulted in an
121 inconsistent change in the blue color. This may have been caused by the degradation of the color pigment, which
122 may have resulted from the heating process [15].
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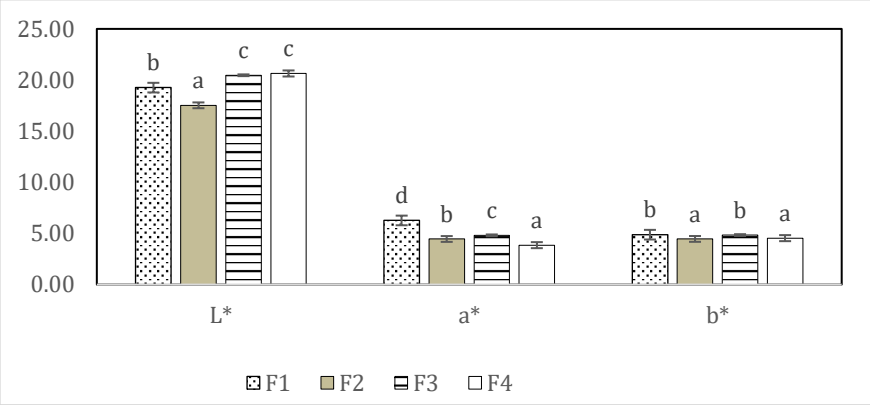

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125 **Fig 1**. Three dimensions colours of the jelly candy in different concentration of
126 porang macerated with Strobilanthes crispus: L* (lightness), a* (redness: green
127 to red), b* (yellowness: blue to yellow). F1, F2, F3, and F4 were the jelly candy
128 with the concentration of 0.2, 0.5, 0.7, 0.9%, respectively.
129

130 **3.3. Texture profile**

131 Table 2 shows the effect of PMS concentration on the texture profiles of the jelly candy. In this study, the
132 hardness values decreased gradually and significantly with increasing concentrations, from 56.4 N in F1 to 19.42 in
133 F4 ($p < 0.05$). This observation is different from that of previous research that used carrageenan and pectin as
134 hydrocolloids. It was reported that hardness increased with increasing hydrocolloid concentration [16].
135 Glucomannan is an active compound that has been proven to have the ability to absorb up to 200 mL of water per
136 gram [17] and form a gel [18]. This water absorption ability was influenced by the hydroxyl, carbonyl, and acetyl
137 groups [18]. The gel-forming ability of glucomannan was synergistic with that of carrageenan [19], but in this study,
138 the gel strength was weakened. This was possible because the glucomannan in PMS may not have effectively
139 bonded with carrageenan and gelatin. The addition of PMS decreased the concentration of carrageenan, which
140 increased the gel strength of the candy [16]. Moreover, the strong hydrogen bonds in glucomannan affected its
141 inability to absorb water, resulting in incomplete gel formation.

142 The cohesiveness values of candy were in the range of 0.62–0.67 (Table 2). F1 was not significantly different
143 from F2 and F3. Only F3 showed a value different from that of F4. This value is relatively higher than those reported
144 in a previous study that used carrageenan and pectin (0.31–0.33) [16]. The cohesiveness values indicated internal

bond strength, so the lower the value, the smaller the internal bond strength, and the easier it is to chew [20].

The adhesiveness values of the jelly candy (Table 2) were not significantly different at all PMS concentrations ($p > 0.05$). This means that the addition of PMS did not change the adhesiveness value. The adhesiveness values indicated the level of stickiness or ability to stick to other objects around the candy, such as packaging and plates [21]. Compared to the results of a prior study that used gelatin as a hydrocolloid, this was relatively higher [22].

The gumminess of the candy declined with increasing PMS concentration ($p < 0.05$) (Table 2). This value was positively related to the hardness value and is defined as the energy required to reduce the size of food [11,16]. In this study, the gumminess values appeared to significantly decline from 35.11 to 13.05, which was in line with the reduction in hardness values. These values were also lower than those of other candies made with hydrocolloids of carrageenan and pectin [11]. This was due to the different ratios of carrageenan and konjac used. Moreover, konjac was used as pure flour, whereas porang was used as raw flour.

The fracture values of the jelly candy in this study were almost similar at all PMS concentrations, except for F4, which had a significantly lower value ($p < 0.05$) (Table 2). The lower value was related to the ease of breaking [23].

The springiness values were generally not significantly different in almost all samples, with the values ranging from 0.89 to 0.91, except for F3, which proved to be the lowest ($p < 0.05$) (Table 2). These values were often related to the elasticity, that is, the ability to return to the original shape after deformation. The springiness value in this study had the same tendency as in previous research, especially because it was inversely proportional to the hardness value [11].

The chewiness values of the jelly candy tended to decrease with increasing PMS concentration ($p < 0.05$) (Table 2). This was not in line with another study that found an increase in the chewiness value with an increase in hydrocolloids, especially carrageenan [22] [16]. In this study, the concentrations of carrageenan and gelatin decreased with increasing PMS concentration, reducing chewiness.

Table 2. Texture profiles of jelly candy with different concentrations of porang macerated with *Strobilanthes crispus*

Texture parameters	F1	F2	F3	F4
Hardness bite 1 (N)	56.40 ± 5.27^{d}	47.58 ± 1.62^{c}	41.08 ± 3.16^{b}	19.42 ± 1.41^{a}
Cohesiveness	0.62 ± 0.30^{ab}	0.66 ± 0.03^{b}	0.60 ± 0.01^{a}	0.67 ± 0.03^{b}
Adhesiveness (Nmm)	0.47 ± 0.28^{a}	0.80 ± 0.20^{a}	0.93 ± 0.45^{a}	0.78 ± 0.24^{a}
Gumminess	35.11 ± 2.23^{d}	31.19 ± 0.75^{c}	24.51 ± 2.44^{b}	13.05 ± 0.55^{a}

Fracture (N)	2.64±0.19[b]	2.44±0.09[b]	2.37±0.12[b]	2.09±0.15[a]
Springiness index	0.91±0.02[b]	0.91±0.01[b]	0.87±0.02[a]	0.89±0.01[b]
Chewiness	3.17±2.08[d]	2.84±0.94[c]	2.12±1.97[b]	1.17±0.59[a]

Notes: F1, F2, F3, and F4 were the jelly candy with the concentration of 0.2, 0.5, 0.7, 0.9%, respectively.

4. CONCLUSIONS

This study found that addition distinctive concentration of PMS affected the preferences of texture and taste. The physical measurement of lightness (L) and redness (a) was also affected. For the texture profiles, increasing the PMS concentration caused a decrease in hardness bite 1, gumminess, fracture, and chewiness but an increase in cohesiveness. It did not affect adhesiveness and springiness. This research is important for developing new food products as sustainable food sources and determining the governance of food security.

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CONFLICT OF INTEREST AND FUNDING DISCLOSURE

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Commitment to scholarly publishing ethics and introduction of the connector author

We, the authors of the article entitled " Sensory and Physical Properties of Jelly Candy Added with Porang (Amorphophallus oncophyllus) Macerated with Strobilanthes crispus as A Low-Sugar Food Product."

approve to send this article to Journal of Food Science and Technology (Iran) and declare that this article is not under revision in any other scholarly journals at the time of submission to Journal of Food Science and Technology (Iran) and will not be sent to any other scholarly journal during the revision at Journal of Food Science and Technology (Iran) until the definite answer about it. We choose ... (one of the authors) as the **connector author** and delegate all the responsibility of the article to him/her regarding to follow the relation with the Journal of Food Science and Technology (Iran).

Disclosure of Potential Conflicts of Interests

If this article is extracted from a dissertation or research project, write down its specifications:

Our research project title was The Development of Neutraceutical Products from Porang (*Amorphophallus oncophyllus)* Macerated with *Strobilanthes crispus* (PMS). The research was divided into three steps, namely 1) teratogenic study of PMS; 2) Production of jelly and drinking Product; 3) Clinically study of the product. This paper is one of the output from step 2.

Who have funded the research that has resulted in production of this article?

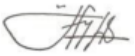
The study was funded by DRTPM Ditjen Diktiristek, Kemdikbudristek Republik Indonesia through PTUPT 2023

Clearly mention the potential conflicts of interest between each of the contributing factors in the production of this article (sponsors, scholars, and writers).

All authors have no conflict of interest in this article.

Introducing the authors, their order of appearance and their contribution

We, the authors (names and orders of appearance are as the below table), by awareness of the non-changeability of the names, orders of appearance and information of authors (no authors can be added or removed at all) declare that we all have contributed in producing this article (doing the researches or writing the article) and no names have been added without having an effective role to the article. From the following authors, the row No 1 is introduced as the correspondent author whose name will come as this on the published article. Corresponding author Email: verianiaprilia@almaata.ac.id

Order	Name[1]	Last Degree[2]	Affiliation[3]	Contribution[4]	Signature[5]
1	Veriani Aprilia	Doctor of Food Science	Department of Nutrition, Universitas Alma Ata	- Project leader - Design the concept	
2	Nurul Kusumawardani	Master of Pharmacy	Department of Pharmacy, Universitas Alma Ata	Design the concept	
3	Rizal Fauzi	Master of Pharmacy	Department of Pharmacy, Universitas Alma Ata	Design the concept	
4	Daru Estiningsih	Doctor of Pharmacy	Department of Pharmacy, Universitas Alma Ata	Design the concept	
5	Effatul Afifah	Doctor of Nutrition	Department of Nutrition, Universitas Alma Ata	Formulation of jelly	
6	Dwi Kusumawati	Bachelor of Nutrition	Department of Nutrition, Universitas Alma Ata	Production of jelly, evaluation of the product	
7	Imroatul Anifa	Bachelor of Nutrition	Department of Nutrition, Universitas Alma Ata	Production of jelly, evaluation of the product	
8	Aprilinna Effendi	Bachelor of Nutrition	Department of Nutrition, Universitas Alma Ata	Production of jelly, evaluation of the product	

[1] The whole name of each person as it should be written in the article;

[2] Such as PhD, MSc, MD, etc.

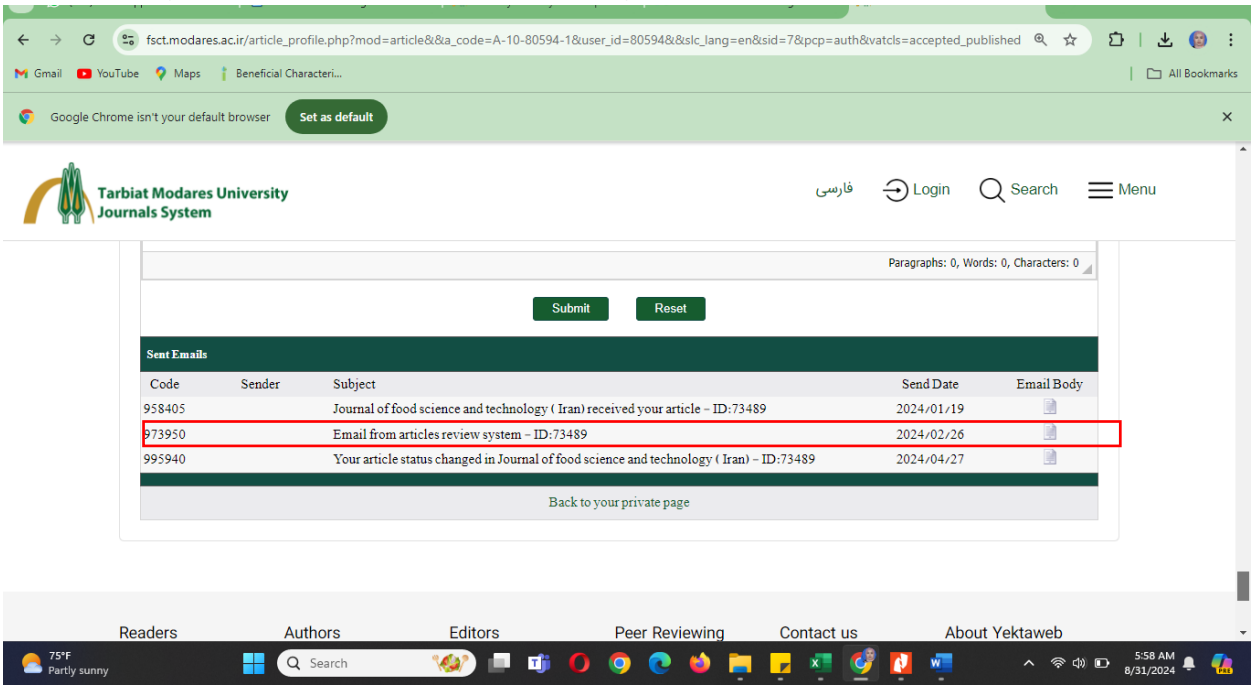
[3] Affiliation for each author must be accurately as

"Group or Department, School or Research Center, University or Institute, City, Country"

[4] Main/Subsidiary Researcher, Data Analyzer, Writer of the Introduction, Writer of the Discussion, or Methodologist; the contribution must be declared as percentage (must be 100% as whole).

[5] Each author MUST sign his/her name row.

2. Proses Reviu (19 Januari 2024 s.d. 26 Februari 2024)



Reviewers **Comments:**

1. **The title:** It is better to mention the full scientific name of the plant in the text of the manuscript (introduction section) in form of *italic*.

Introduction:

2. Line 48: What is the reason for the abundance of glucomannan, especially in porang flour? Its numerical value should be mentioned.

3. Line 49: What is the amount of calcium oxalate in Porang flour? Its toxicity on kidney function will not prevent its use in this study? Give more explanation. If possible, more similar nutritional studies of Porang powder should be mentioned? Being limited to a general reference cannot be a justification for the non-toxicity of this herbal compound. The authors should use the toxicity test of this compound in their study.

4. Line 54: The abbreviation of this plant (*Strobilanthes crispus*) should be mentioned in the first mention of its name in the text. Please, revised it.

5. Line 55-56: The authors claim or expect that this jelly candy will lead to lower blood glucose levels. However, in the materials and methods section, there is no mention of blood glucose measurement and the tools used.

In Materials and methods section:

2.2 Production of jelly candy with PMS added: The production formulation of this jelly should be mentioned briefly.

In result section:

1. According to the format of the journal, the results and discussion sections should be separate. The results of the manuscript should be presented in a concise form. In the discussion section, the results should be compared and interpreted with similar studies in this field.

2. Fig 1. Colour or color? The writing style should be the same in all parts of the manuscript (see **2.4. Color measurement section**).

3. 3.1. Sensory properties, line 95: Overall. should be modified to overall acceptance.

4. 3.1. Sensory properties, line 98-100: Authors claimed that «The taste attribute was mainly influenced by the inclusion of dragon fruit, while the texture was affected by the combination of polysaccharides of gelatine, glucomannan in PMS, and carrageenan [11]», in this study, what connection was observed between dragon fruit and porang macerated with Strobilanthes

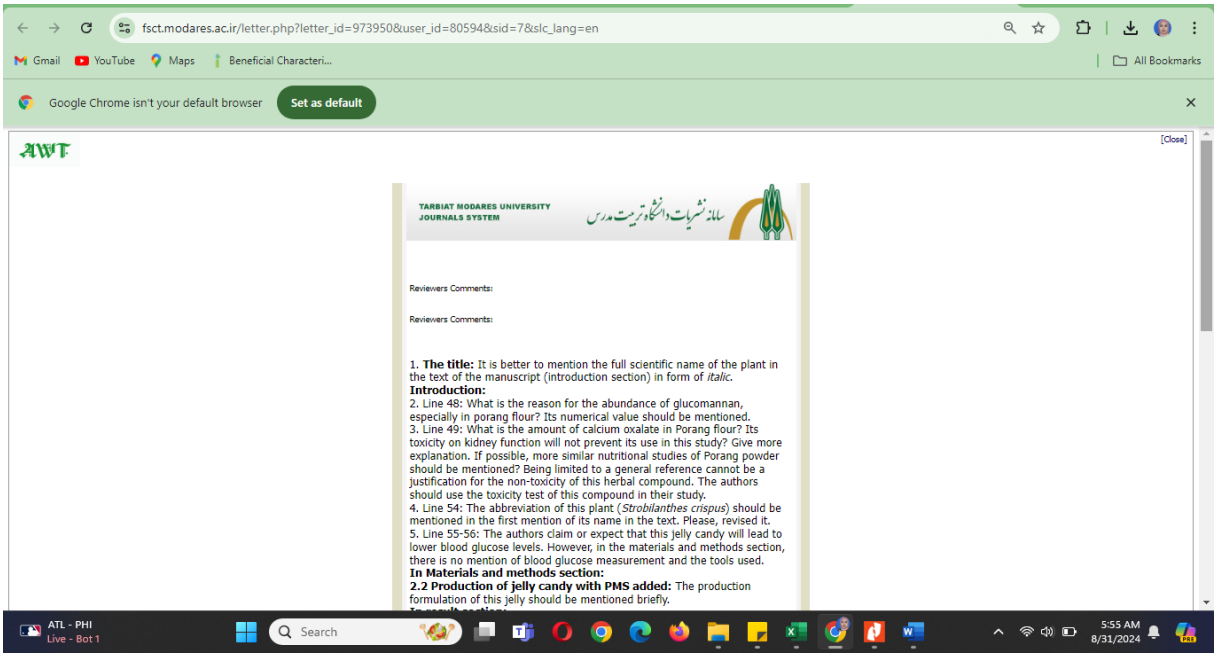
crispus? The referenced reference is unrelated to this study. Are its results reliable?

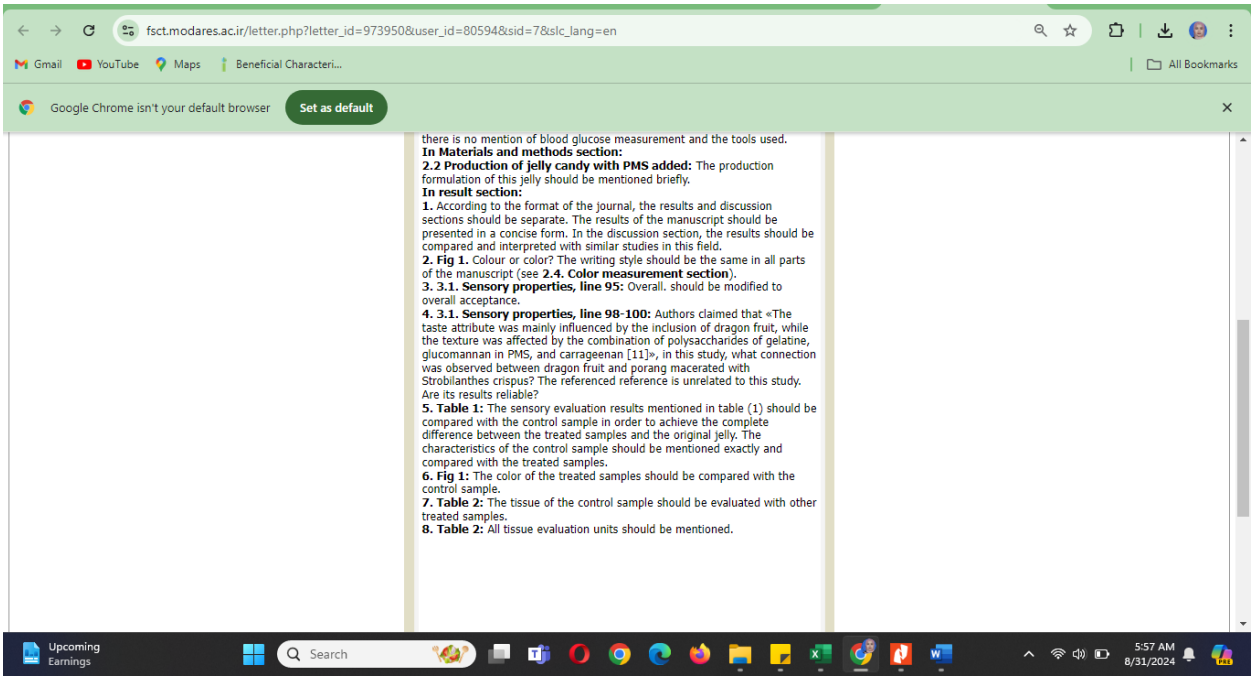
5. Table 1: The sensory evaluation results mentioned in table (1) should be compared with the control sample in order to achieve the complete difference between the treated samples and the original jelly. The characteristics of the control sample should be mentioned exactly and compared with the treated samples.

6. Fig 1: The color of the treated samples should be compared with the control sample.

7. Table 2: The tissue of the control sample should be evaluated with other treated samples.

8. Table 2: All tissue evaluation units should be mentioned.

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All Bookmarks
Google Chrome isn't your default browser
Set as default
there is no mention of blood glucose measurement and the tools used.
In Materials and methods section:
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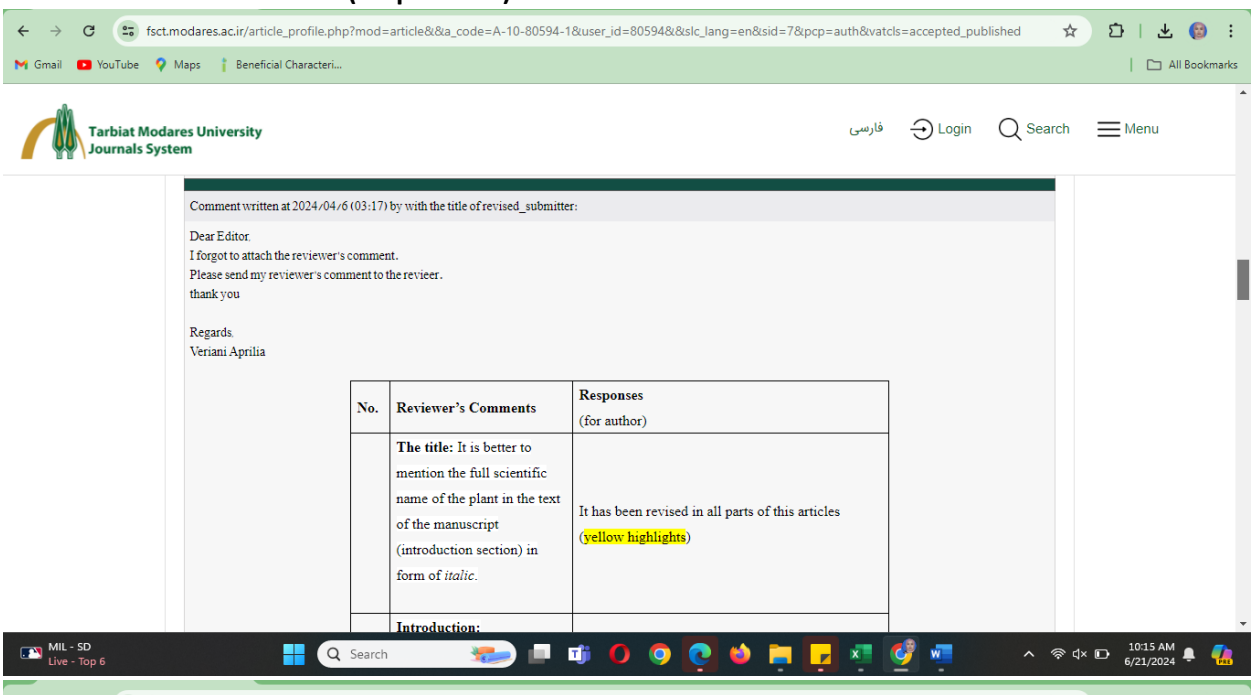

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No.	Reviewer's Comments	Responses (for author)
	The title: It is better to mention the full scientific name of the plant in the text of the manuscript (introduction section) in form of *italic*.	It has been revised in all parts of this articles (yellow highlights)
	Introduction:	

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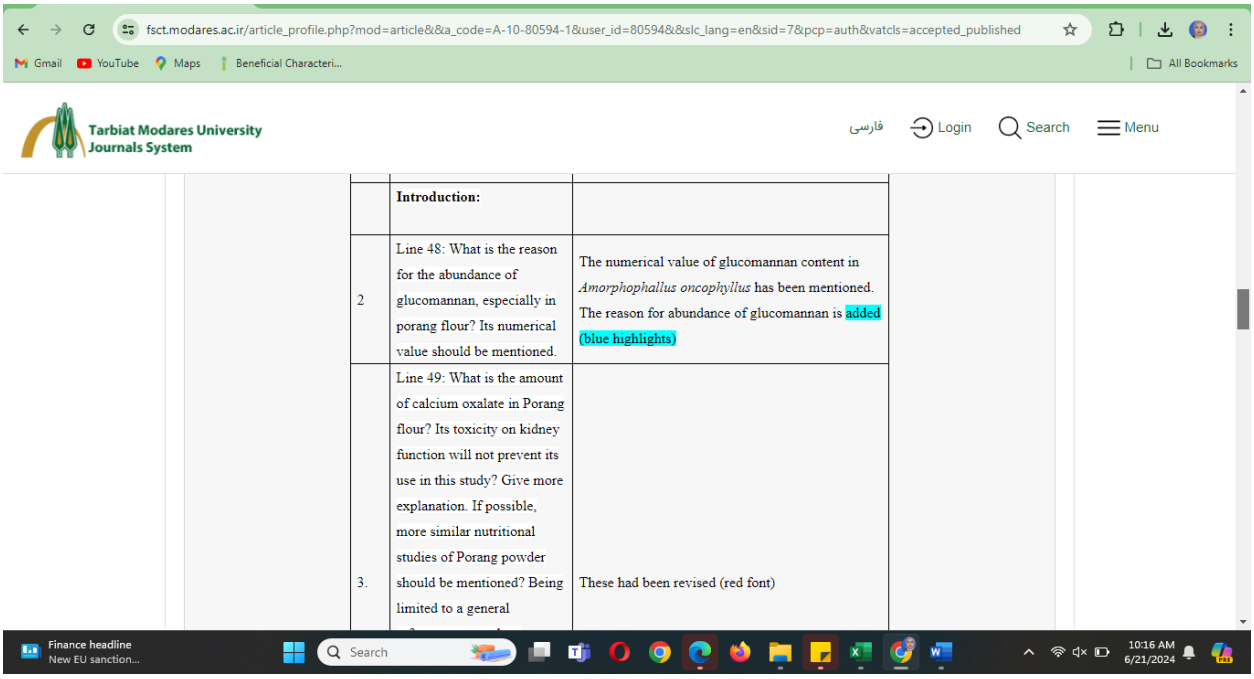

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	Introduction:	
2	Line 48: What is the reason for the abundance of glucomannan, especially in porang flour? Its numerical value should be mentioned.	The numerical value of glucomannan content in *Amorphophallus oncophyllus* has been mentioned. The reason for abundance of glucomannan is added (blue highlights)
3.	Line 49: What is the amount of calcium oxalate in Porang flour? Its toxicity on kidney function will not prevent its use in this study? Give more explanation. If possible, more similar nutritional studies of Porang powder should be mentioned? Being limited to a general	These had been revised (red font)

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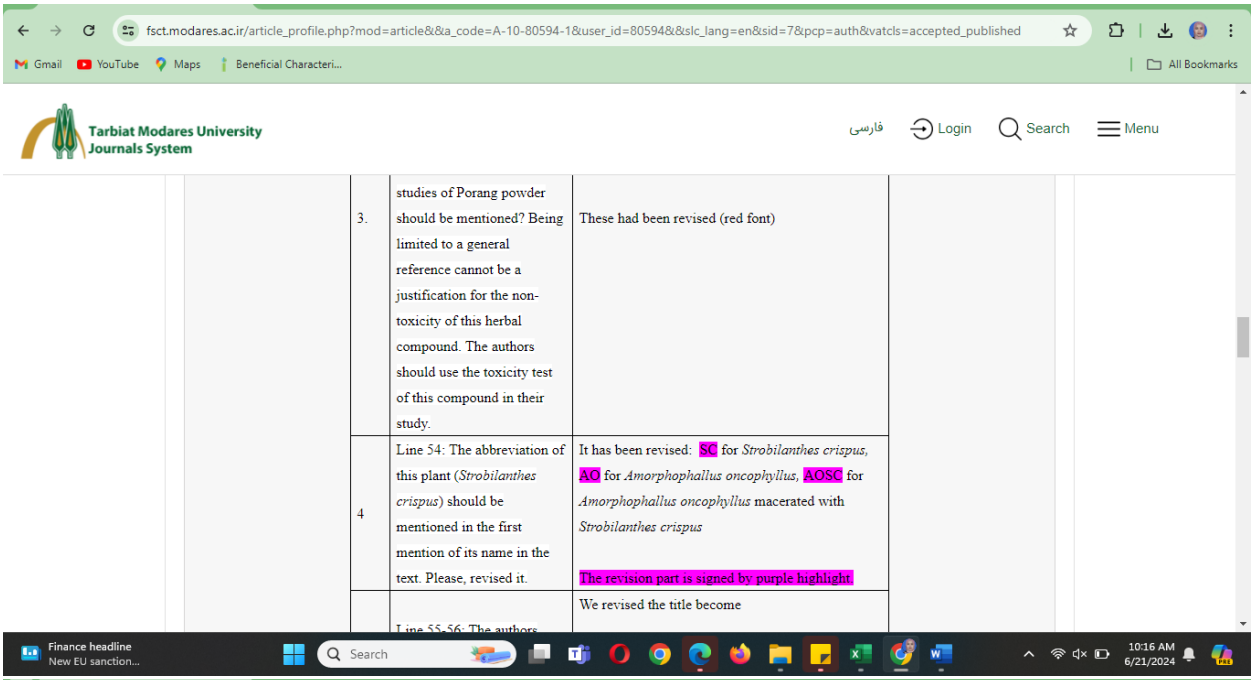
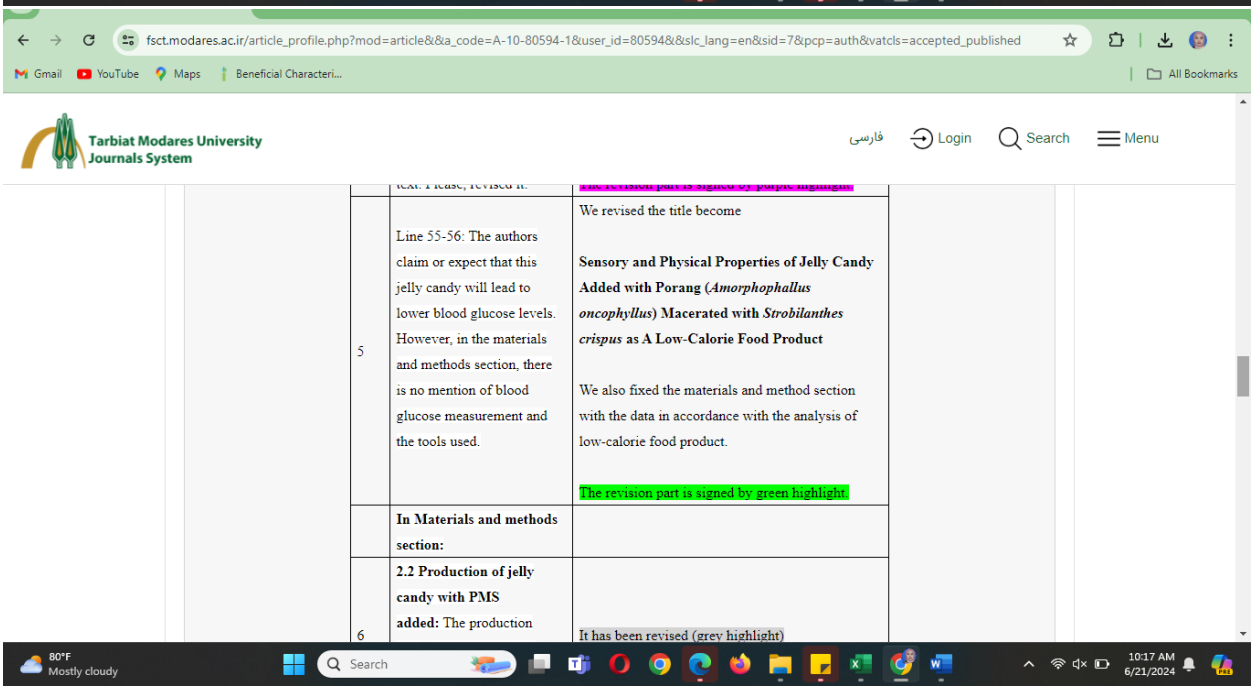
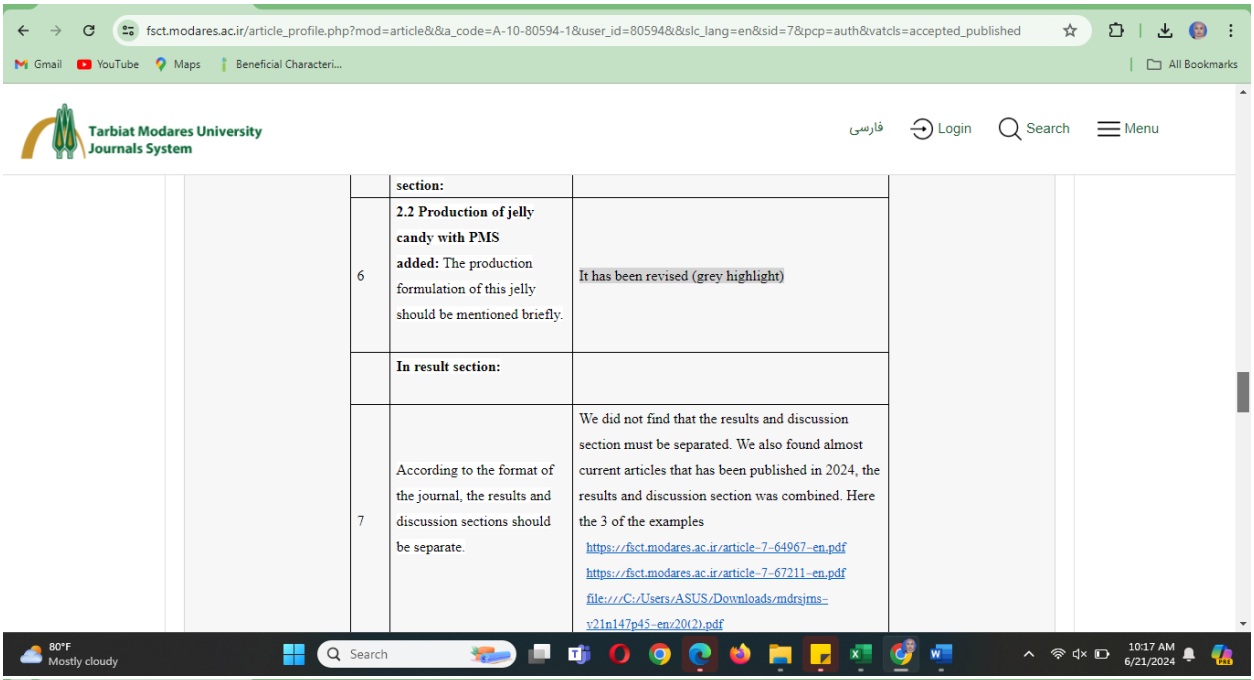


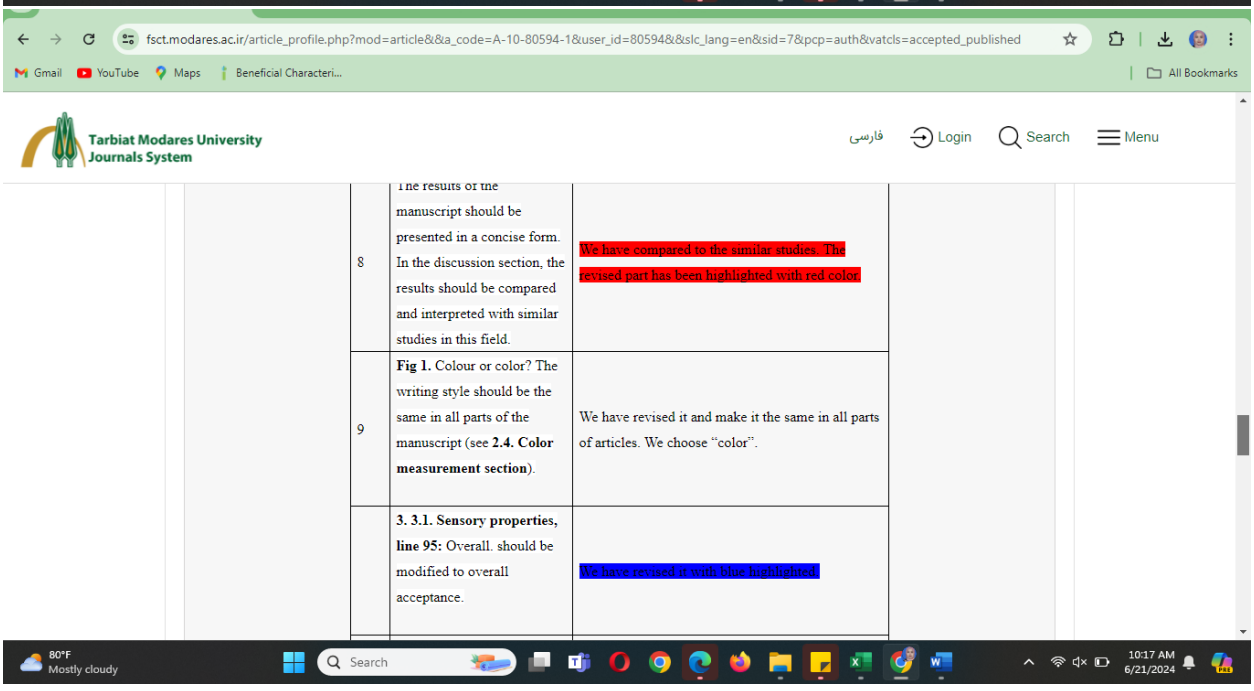
3.	studies of Porang powder should be mentioned? Being limited to a general reference cannot be a justification for the non-toxicity of this herbal compound. The authors should use the toxicity test of this compound in their study.	These had been revised (red font)
4	Line 54: The abbreviation of this plant (*Strobilanthes crispus*) should be mentioned in the first mention of its name in the text. Please, revised it.	It has been revised: SC for *Strobilanthes crispus*, AC for *Amorphophallus oncophyllus*, AOSC for *Amorphophallus oncophyllus* macerated with *Strobilanthes crispus* The revision part is signed by purple highlight.
	Line 55-56: The authors	We revised the title become



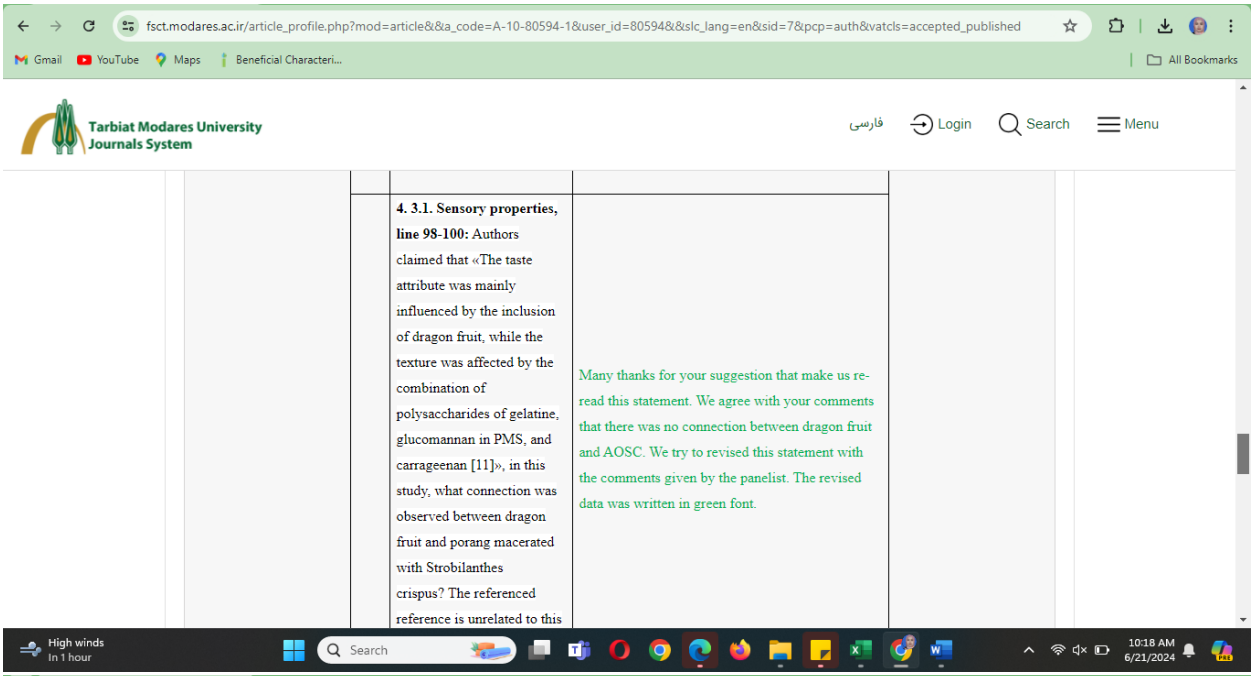
	text. Please, revised it.	The revision part is signed by purple highlight.
5	Line 55-56: The authors claim or expect that this jelly candy will lead to lower blood glucose levels. However, in the materials and methods section, there is no mention of blood glucose measurement and the tools used.	We revised the title become **Sensory and Physical Properties of Jelly Candy Added with Porang (*Amorphophallus oncophyllus*) Macerated with *Strobilanthes crispus* as A Low-Calorie Food Product** We also fixed the materials and method section with the data in accordance with the analysis of low-calorie food product. The revision part is signed by green highlight.
	In Materials and methods section:	
6	**2.2 Production of jelly candy with PMS added:** The production	It has been revised (grey highlight)



	section:	
6	**2.2 Production of jelly candy with PMS added:** The production formulation of this jelly should be mentioned briefly.	It has been revised (grey highlight)
	In result section:	
7	According to the format of the journal, the results and discussion sections should be separate.	We did not find that the results and discussion section must be separated. We also found almost current articles that has been published in 2024, the results and discussion section was combined. Here the 3 of the examples https://fsct.modares.ac.ir/article-7-64967-en.pdf https://fsct.modares.ac.ir/article-7-67211-en.pdf file:///C:/Users/ASUS/Downloads/mdrsjms-v21n147p45-en(2).pdf



8	The results of the manuscript should be presented in a concise form. In the discussion section, the results should be compared and interpreted with similar studies in this field.	We have compared to the similar studies. The revised part has been highlighted with red color
9	**Fig 1.** Colour or color? The writing style should be the same in all parts of the manuscript (see **2.4. Color measurement section**).	We have revised it and make it the same in all parts of articles. We choose "color".
	3. 3.1. Sensory properties, line 95: Overall. should be modified to overall acceptance.	We have revised it with blue highlighted



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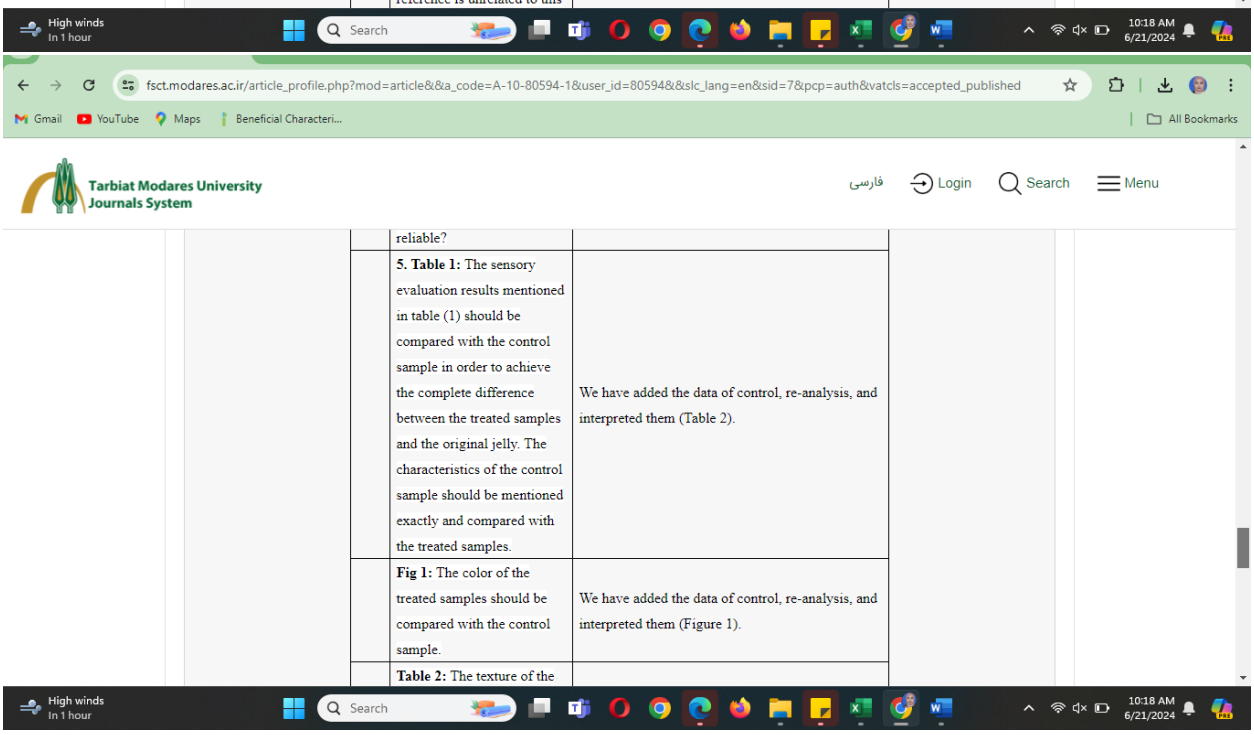

	reliable?	
	5. Table 1: The sensory evaluation results mentioned in table (1) should be compared with the control sample in order to achieve the complete difference between the treated samples and the original jelly. The characteristics of the control sample should be mentioned exactly and compared with the treated samples.	We have added the data of control, re-analysis, and interpreted them (Table 2).
	Fig 1: The color of the treated samples should be compared with the control sample.	We have added the data of control, re-analysis, and interpreted them (Figure 1).
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	Table 2: The texture of the control sample should be evaluated with other treated samples.	We have added the data of control, re-analysis, and interpreted them (Table 3).
	Table 2: All tissue evaluation units should be mentioned.	We have revised it.

Sensory and Physical Properties of Jelly Candy Added with Porang (*Amorphophallus oncophyllus*) Macerated with *Strobilanthes crispus* as A Low-Calorie Food Product

ABSTRACT

Porang (*Amorphophallus oncophyllus, AO*) is a local food source that may be developed to address food security concerns. Diversification in processing should be done to increase its consumption. *Amorphophallus oncophyllus* macerated with *Strobilanthes crispus* (AOSC) was added to jelly candy, which was created as a low-calorie food product with useful antihyperglycemic qualities. This study aimed to evaluate the sensory and physical properties of jelly candy, including color and texture. Jelly candy varied in the concentration of AOSC, namely: 0.2, 0.5, 0.7, and 0.9%. The content of macronutrients was analyzed to prove the calorie value of jelly. The sensory evaluation was carried out using a hedonic scale, while color and texture profiles were each analyzed using a chromameter and texture analyzer. Adding AOSC considerably decreased the calorie content of jelly by up to 35%, from 147 Kcal/100 g to between 94.74 and 104.18 Kcal/100 g. In comparison to the control, the addition of AOSC had the same degree of preference in practically every attribute and did not affect total preferences. Additionally, it raised the yellow-blue component (b* value) and the lightness (L* value), but decreased the red-green component (a* value). While the cohesiveness, gumminess, and fracture values of the jelly candy decreased and the hardness values increased, the addition of AOSC did not affect the springiness value. The results of this research will be crucial in the development of new food products, particularly those that are low in calories and appealing to customers due to their improved physical qualities.

Keywords: *Amorphophallus oncophyllus*, *Strobilanthes crispus*, texture, color, sensory

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1. INTRODUCTION

Food security relates to fulfilling a person's food and ensuring it is of sufficient quantity and quality, while also ensuring it is safe, diverse, nutritious, equitable, and affordable so that one can live a healthy and productive life [1]. Food security can be indicated by the number of nutritional problems in a country. According to UNICEF

data, the prevalence of malnutrition, calculated from the number of stunting cases, reached 22.3% in 2022. This prevalence has decreased since 2020, but the decline is gentle at around 0.2-0.3% per year. On the other hand, between 2005 and 2022, the problem of overnutrition has not decreased, constantly at the number of 5.5%[2]. Based on this phenomenon, food security is still a global problem. Apart from insufficient food sources leading to malnutrition, welfare inequality also led to overnutrition in certain populations.

The prevalence of overnutrition is not as high as the prevalence of undernutrition, but this problem has not decreased from year to year. Handling overnutrition status is important because it risks the occurrence of metabolic diseases, such as diabetes mellitus (DM). This disease is still the cause of death in the world [3]. DM patients, apart from using drugs and herbs, can also use medical nutritional therapy. In medical nutrition therapy, it is important to pay attention to the regularity of the eating schedule, type, and number of calories of food consumed [4].

Low-calorie staple foods and snacks for people with DM have been developed. *Amorphophallus oncophyllus* (AO) or a tuber known locally as porang has a high concentration of the beneficial compound glucomannan, reaching 59-65% [5]. Glucomannan has been widely available and its demand has substantially increased. Its global market size in 2022 was reported at US dollar 1.47 Bn and is expected to reach US dollar 1.83 Bn in 2029 [6]. It is necessary because of its health benefits that has been investigated in several contexts. Research findings have validated the nutritional benefits of this food, including its ability to reduce weight by satisfying hunger and promoting fullness [7], control hyperglycemia, and hypercholesterolemia [8][9], and improve digestive tract health [10]. The application of glucomannan is becoming more widespread mainly in food and pharmaceuticals include encapsulation, emulsion, biodegradable film, thickener, binder, and many more [11].

However, the use of pure glucomannan is limited because of its great price. The consumption of raw AO may be considered as another way to consume glucomannan. Raw AO was more nutritious than pure glucomannan as particularly it not only contained carbohydrates and fiber, but also had protein, fat, mineral, and starch [12]. Unfortunately, there was calcium oxalate in raw AO that may cause itching and long-term consumption had a risk of kidney stones formation [13]. Naturally, the calcium oxalate in raw AO varies between 3.08-22.72% [14][15]. Several methods, such as the use of ball mills, stamp mills, fractionation blowers, and chemicals such as ethanol, ash, and sodium chloride, have been tried to reduce the amount of calcium oxalate in raw AO [16][17][18]. Another way to lower the calcium oxalate concentration of AO was to employ an herbal approach by maceration with a *Strobilanthes crispus* (SC) ethanolic extract. Preview research had demonstrated that it worked better than using ethanol by itself. By using this method, the lowest amount of calcium oxalate could be reached, which was 0.2% [13].

AO that has been macerated with an SC ethanolic extract had the special health benefits of reducing blood glucose levels which is comparable to glibenclamide (commercial drug) and was better than using AO alone [8]. The

study of toxicity reported that AO macerated with SC ethanolic extract (AOSC) was safe to consume [19][20].

Raw AO has been widely applied to food products, but it still needs diversification to increase consumption. The development of jelly candy added with AOSC was carried out as a low-calorie food product. This study aimed to evaluate the sensory and physical properties of this jelly candy, including its color and texture.

2. MATERIALS AND METHODS

2.1. Materials

AO was obtained from the Porang Nusantara Activist Association branch of Boyolali, North Java, Indonesia. The AOSC was then produced based on an Indonesian submission patent (no S00202006668) [21].

2.2. Production of jelly candy with AOSC added

The jelly candy was made from 17.5% mixed gum (carrageenan, jelly flour, gelatin) and dragon fruit, corn sugar, citric acid, and strawberry flavor, based on an Indonesia submission patent (no S00202211830) [22]. The materials were mixed, cooked, and molded [23]. The AOSC was added in different concentrations (0, 0.2, 0.5, 0.7, and 0.9% for F0, F1, F2, F3, and F4, respectively).

2.3. Analysis of macronutrient and energy values

Macronutrient analysis was based on the Association of Official Analytical Chemists (AOAC) [24]. The energy values of jelly candy were then calculated using the Atwater factor [25].

2.4. Sensory analysis

The preferences for jelly candy were analyzed by hedonic test using 30 semi-trained panelists. The inclusion criteria of panelists were had passed the sensory lesson, were healthy, not drinking, not smoking, and were willing to be a panelist. The panelists were asked to eat the samples and write their preferences of color, taste, flavor, texture, and overall acceptance [26]. A five hedonic scale was used with 1 (extremely dislike), 2 (dislike), 3 (slightly like), 4 (like), 5 (extremely like).

2.4. Color measurement

The colors of jelly were expressed in three dimensions: lightness L*, redness a*, and yellowness b*. These colors were measured by using a chromameter CR-400 (Konica Minolta Business Technologies, Inc., Tokyo, Japan). The chromameter was adjusted for illuminant C. It was then standardized using a white reflector plate. The color of the jelly was measured by using the base material color measurement apparatus.

2.5. Texture profile analysis

A texture profile analysis was performed as hardness bite 1, gumminess, fracture, chewiness, cohesiveness, adhesiveness, and springiness index. These elements were analyzed using a CT3 texture analyzer (Brookfield Engineering Laboratories, Inc., USA).

2.6. Statistical analysis

Software called SPSS 16.0 was utilized for statistical analysis. A one-way analysis of variance (ANOVA) was used to analyze the data. Duncan's multiple range test (DMRT) was used to compare means at $p<0.05$.

3. RESULTS AND DISCUSSION

3.1. Macronutrient and energy values

Table 1. Macronutrient and energy values of jelly candy in different concentration of *Amorphophallus oncophyllus* macerated with *Strobilanthes crispus* (AOSC)

Macronutrient and Energy Values	F0	F1	F2	F3	F4
Fat (%)	0.46±0.01^{d}	0.07±<0.01^{c}	0.06±<0.01^{bc}	0.05±<0.01^{ab}	0.04±<0.01^{a}
Protein (%)	15.06±0.23^{b}	15.63±0.24^{c}	14.58±0.13^{a}	14.29±0.02^{a}	14.18±0.04^{a}
Carbohydrate (%)	20.80±0.08^{e}	8.36±0.23^{a}	11.34±0.24^{d}	10.69±0.03^{c}	9.42±0.14^{b}
Energy values (Kcal/100 g)	147.56±0.47^{e}	96.58±0.09^{b}	104.18±0.46^{d}	100.35±0.03^{c}	94.74±0.72^{a}

Notes: F0, F1, F2, F3, and F4 were the jelly candy added AOSC with the concentration of 0 (control), 0.2, 0.5, 0.7, 0.9%, respectively. Means with distinctive letters within the same row are significantly different ($p<0.05$).

The addition of AOSC significantly reduced fat, protein, and carbohydrate levels when compared to controls ($p<0.05$) (Table 1). In detail, the more AOSC added to the jelly, the lower the fat and carbohydrate content, while the decrease in protein content only occurred with the addition of 0.2% AOSC. The addition of 0.5, 0.7, and 0.9% of AOSC did not result in a decrease in protein levels.

The values of the macronutrients might be used to calculate the calories. The calories in jelly were considerably decreased by up to 35% when AOSC was added, from 147 Kcal/100 g to approximately 94.74–104.18 Kcal/100 g. Jelly candy can be served as much as 10 grams for each consumption and contains around 9.47-10.42

Kcal per piece of jelly candy. The main focus of dietary energy restriction for the management and treatment of type 2 diabetes has been weight loss using low-calorie diets (1200–1500 kcal/day) or very low-calorie diets (about 400–800 kcal/day) [27]. Snack foods typically provide around 15% of daily energy needs [4] or around 225 Kcal per day. With a fairly low number of calories per item, 9.47-10.42 Kcal/candy, this jelly candy is safe for diabetes sufferers to consume up to around 21 pieces of candy per day.

3.2. Sensory properties

Thirty panelists scored the sensory attributes based on the preference or acceptance of color, flavor, taste, texture, and overall. The preference scores were above 3 in all sensory attributes which means jelly was slightly liked. Table 2 shows that the addition of AOSC did not affect the overall acceptance of jelly candy ($p>0.05$). In addition, for each attribute assessed, several formulas appeared to have the same level of preference compared to the control ($p>0.05$). For example, in the color attribute, adding AOSC to a concentration of 0.7% (F3) did not reduce the panelists' level of preference, as did the flavor attribute. Even on the texture attribute, the level of control preference was not significantly different from all treatments ($p>0.05$). The highest scores of preferences for taste and texture were observed in F3 samples. Some of the panelists commented that they received the taste of jelly candy mainly from dragon fruit. They also described the texture of jelly candy as less-chewy, but had the unique grainy texture from the presence of AOSC. The less-chewy may be caused by the inappropriate composition of polysaccharides in jelly candy, like gelatine, glucomannan in AOSC, and carrageenan [28]. In previous research, it was proven that konjac flour plays a role in forming a viscous solution, while κ-carrageenan forms a heat-induced, brittle (hard) gel upon cooling [29]. This sensory information is needed in the food industry to describe the acceptability of consumers [26].

Table 2. Sensory properties of jelly candy in different concentration of *Amorphophallus oncophyllus* macerated with *Strobilanthes crispus* (AOSC)

Sensory Attributes	F0	F1	F2	F3	F4
Color	4.06±0.77^{b}	3.90±0.71^{ab}	3.87±0.63^{ab}	3.70±0.70^{ab}	3.57±0.82^{a}
Flavor	3.94±0.63^{b}	3.43±0.77^{a}	3.60±0.72^{ab}	3.53±0.94^{ab}	3.20±0.89^{a}
Taste	4.00±0.86^{c}	3.40±0.77^{ab}	3.40±0.81^{ab}	3.73±0.83^{bc}	3.13±0.97^{a}
Texture	3.42±0.99^{ab}	3.23±0.63^{a}	3.53±0.94^{ab}	3.73±0.87^{b}	3.20±0.89^{a}
Overall acceptance	3.68±0.65^{a}	3.33±0.66^{a}	3.57±0.77^{a}	3.70±0.75^{a}	3.33±0.99^{a}

Notes: F0, F1, F2, F3, and F4 were the jelly candy added AOSC with the concentration of 0 (control), 0.2, 0.5, 0.7, 0.9%, respectively. Means with

distinctive letters within the same row are significantly different ($p<0.05$).

3.3. Color properties

Based on Figure 1, the lightness (L*) values of jelly candy were in the range of 17.53–20.64, which indicated white. Some treatment groups like F1 and F2 had lower values than the control, while F3 and F4 had the same value as the control. This indicates that the higher concentration of AOSC could increase the brightness of the candy. The jelly candy used in this study had a dark purple coloration due to the addition of a natural colorant from dragon fruit. Theoretically, there were also yellow carotene and polyphenols in the AOSC that were susceptible to oxidation, which resulted in a brown color [30][31][32].

The a* values of the control was declined significantly compared to the treatment group ($p<0.05$), yet the treatment groups had almost the same values in the range of 3.85–6.27 (Figure 1). The a* values indicated the red colors of the jelly. The red color in the jelly candy is influenced by the betacyanin pigment of the dragon fruit [33]. The addition of AOSC reduced the concentration of betacyanin in the candy, thus reducing the redness.

The b* values of the candy were in the range of 4.54–4.88 (Figure 1). The addition of AOSC resulted in a bit higher of b* values. The b* value indicated the blue color. This may have been caused by the degradation of the color pigment, which may have resulted from the heating process [33].

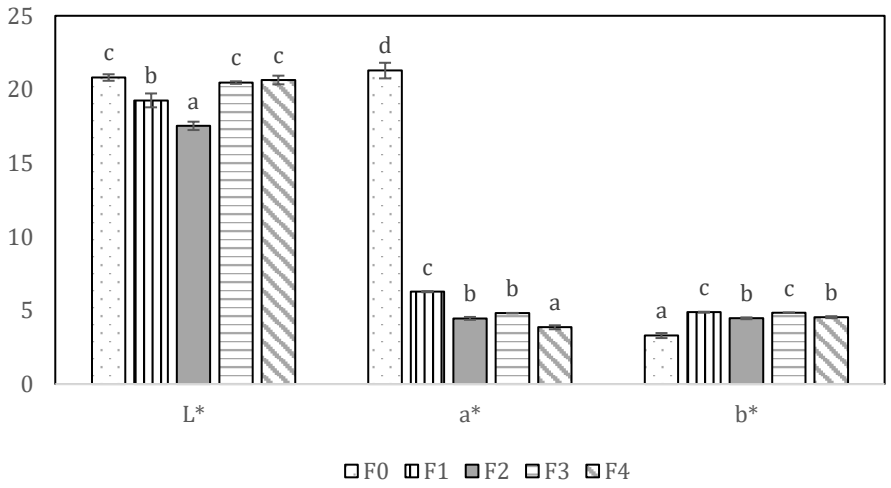

Fig 1. Three dimensions colors of the jelly candy in different concentration of *Amorphophallus oncophyllus* macerated with *Strobilanthes crispus (*AOSC): L* (lightness), a* (redness: green to red), b* (yellowness: blue to yellow). F0, F1, F2, F3, and F4 were the jelly candy with the concentration of AOSC 0 (control), 0.2, 0.5, 0.7, 0.9%, respectively. Various letters (a, b, c) in a group representing

the significant difference among the groups ($p < 0.05$)

3.3. Texture profile

Table 3 shows the effect of AOSC concentration on the texture profiles of the jelly candy. In this study, the addition of AOSC increased the hardness values of jelly candy, proven by the significant differences between treatment samples and control ($p<0.05$). The hardness values decreased gradually and significantly with increasing concentrations, from 56.4 N in F1 to 19.42 in F4 ($p<0.05$). This observation is different from that of previous research that used carrageenan and pectin as hydrocolloids. It was reported that hardness increased with increasing hydrocolloid concentration [34]. Glucomannan is an active compound that has been proven to have the ability to absorb up to 200 mL of water per gram [35] and form a gel [36]. This water absorption ability was influenced by the hydroxyl, carbonyl, and acetyl groups [36]. The gel-forming ability of glucomannan was synergistic with that of carrageenan [37] to form the helical carrageenan and konjac molecules through hydrogen bonding. However, the high interaction between the two gums, particularly at the junction zones, could cause the konjac to stay un-gelled and alter the viscosity characteristics, which would reduce the gel hardness [29]. Moreover, the addition of AOSC decreased the concentration of carrageenan, which increased the gel strength of the candy [34]. The strong hydrogen bonds in glucomannan affected its inability to absorb water, resulting in incomplete gel formation.

The cohesiveness values of candy added with AOSC were in the range of 0.62–0.67 (Table 3). F1 was not significantly different from F2 and F3. Only F3 showed a value different from that of F4. All of the samples were lower than the control ($p<0.05$). This value is relatively higher than those reported in a previous study that used carrageenan and pectin (0.31–0.33) [34]. The cohesiveness values indicated internal bond strength, so the lower the value, the smaller the internal bond strength, and the easier it is to chew [38].

The adhesiveness values of the jelly candy (Table 3) were not significantly different in all AOSC concentrations, including the control ($p > 0.05$). This indicates that the addition of AOSC did not change the adhesiveness value. The adhesiveness values represented the degree of stickiness or ability to adhere to surrounding items, like plates and packaging, for the candy. [39]. Compared to the results of a prior study that used gelatin as a hydrocolloid, this was relatively higher [40].

The addition of AOSC affected the gumminess of jelly candy. It declined with the increasing AOSC concentration ($p < 0.05$) (Table 3). This value was positively related to the hardness value and is defined as the energy required to reduce the size of food [28,34]. In this study, the gumminess values appeared to significantly decline from 35.11 to 13.05, which was in line with the reduction in hardness values. These values were also lower than those of other candies made with hydrocolloids of carrageenan and pectin [28]. This was due to the different

ratios of carrageenan and konjac used. Moreover, konjac was used as pure flour, whereas AO was used as raw flour.

The fracture values of the jelly candy were affected by the addition of AOSC. It was lower when the AOSC was added ($p<0.05$) (Table 3). On the other hand, almost all the treatment samples had the same values in the range of 2.09-2.64 N. The lower fracture value was related to the ease of the candy being broken [41].

The springiness values were generally not significantly different in almost all samples, with the values ranging from 0.89 to 0.92, except for F3, which proved to be the lowest ($p < 0.05$) (Table 3). These values were often related to the elasticity, that is, the ability to return to the original shape after deformation. The springiness value in this study had the same tendency as in previous research, especially because it was inversely proportional to the hardness value [28].

Table 3. Texture profiles of jelly candy with different concentrations of *Amorphophallus oncophyllus* macerated with *Strobilanthes crispus* (AOSC)

Texture parameters	F0	F1	F2	F3	F4
Hardness bite 1 (N)	39.30±0.32^{b}	56.40±5.27^{d}	47.58±1.62^{c}	41.08±3.16^{b}	19.42±1.41^{a}
Cohesiveness	0.74±0.02^{d}	0.62±0.30^{ab}	0.66±0.03^{bc}	0.60±0.01^{a}	0.67±0.03^{bc}
Adhesiveness (Nmm)	0.86±0.32^{a}	0.47±0.28^{a}	0.80±0.20^{a}	0.93±0.45^{a}	0.78±0.24^{a}
Gumminess	28.90±0.98^{c}	35.11±2.23^{d}	31.19±0.75^{c}	24.51±2.44^{b}	13.05±0.55^{a}
Fracture (N)	14.11±0.01^{a}	2.64±0.19^{bd}	2.44±0.09^{cd}	2.37±0.12^{c}	2.09±0.15^{b}
Springiness index	0.92±0.01^{c}	0.91±0.02^{bc}	0.91±0.01^{bc}	0.87±0.02^{a}	0.89±0.01^{b}

Notes: F0, F1, F2, F3, and F4 were the jelly candy with the concentration of AOSC 0 (control), 0.2, 0.5, 0.7, 0.9%, respectively. Means with distinctive letters within the same row are significantly different ($p<0.05$).

4. CONCLUSIONS

This study found that the addition of AOSC significantly reduced the calorie values in jelly by up to 35%, from 147 Kcal/100 g to around 94.74-104.18 Kcal/100 g. The addition of AOSC did not affect the overall acceptance and had the same level of preference in almost each attribute compared to the control. It also increased the L* value (lightness) and the b* value (yellow-blue components), but decreased a* value (red-green component). The addition of AOSC did not affect the springiness value, but increased the hardness values of jelly candy and declined the cohesiveness, gumminess, and fracture values. This research is important for developing new food products, especially as a low-calorie food that is acceptable to consumers with the quality improvement in physical properties.

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CONFLICT OF INTEREST AND FUNDING DISCLOSURE

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4. Proses Penerimaan (*Acceptance*)