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Organoleptic and Textural Quality Improvement of Soybean and Glucomannan-Based Meat Analogs for Obesity Intervention Using Mushrooms and Vegetable Oil

Peningkatan Mutu Organoleptik dan Tekstur Daging Tiruan Berbasis Kedelai dan Glukomanan untuk Intervensi Obesitas Menggunakan Jamur dan Minyak Nabati

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ABSTRACT

Background: Plant-based meat analogs can be an alternative food for obesity intervention because their composition can be engineered according to criteria. The similarity of fiber structure to meat muscle, texture, sensory properties, and nutritional value determines consumer acceptance. Mushrooms have low-fat, high-quality protein, fiber, and nutraceuticals, so they have the potential for meat analogs formulation. Mushrooms also have a fibrous structure that can imitate meat texture and have a savory umami taste. Adding vegetable oil to the meat analogs formula has been shown to maintain its physicochemical properties and shelf life.
Objectives: Improving organoleptic and texture quality of soy and glucomannan-based meat analog for obesity intervention.
Methods: A completely randomized experimental design study was conducted with one control and four treatments. Data collected include texture profile, water-oil holding capacity, browning index, organoleptic, and satiety index test. Data were analyzed by Analysis of Variance followed by Duncan Multiple Range Test.
Results: The use of mushrooms and vegetable oil in the formula affects (p-value<0.05) the aroma, water-oil holding capacity, and texture parameters of hardness bite, gumminess, and chewiness but does not affect (p-value>0.05) the appearance, taste, texture, aftertaste, liking, browning index, and texture parameters of cohesiveness, resilience, and springiness. Enoki mushrooms and corn oil tend to improve the organoleptic quality of meat analogs. The satiety index of meat analog with the addition of enoki mushrooms and corn oil is 110.4%.
Conclusions: Mushrooms and vegetable oils can be used in meat analog formulations to improve their organoleptic and textural qualities.

INTRODUCTION

Obesity management by way of food adjustment can be done by providing food with a nutritional composition suitable for weight loss, namely low in calories and fat but still filling. Plant protein-based meat analogs can be an alternative food for obesity intervention because their composition can be adjusted to meet the specified criteria. Various types of plant proteins, especially from nuts and cereals, have been used as base ingredients for meat analogues[1]. However, meat analogs generally differ from meat in manly mouthfeel, texture, taste, and aroma[2]. Consumer acceptance of meat analogs also depends on how similar their fiber structure is to meat muscle. In addition, meat analogs have a texture like meat and resemble sensory and nutritional properties[3].

In line with technological developments, meat-like structures in meat analog products can be achieved through equipment with extrusion, shearing, and mixing technologies. However, to imitate meat in other sensory characteristics, such as color, aroma, and mouthfeel, non-protein additives must be used[4]. Another problem with plant-based meat products is that they are less juicy than meat because the fat content is much lower, even though fat plays an important role in juiciness[5]. Meat analogs developed from soybeans and glucomannan have physical properties in the form of good cooking loss and water binding capacity. Still, their appearance, taste, and texture cannot resemble meat yet[6].

Edible mushrooms are generally commodities with low-fat content, high-quality protein, rich in dietary fiber, and contain nutraceuticals, so they have the

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potential for low-calorie functional food formulations. Mushrooms also have a fibrous structure that can imitate the texture of meat and unique savory umami taste[7] and can improve nutritional value, sensory properties, and texture[8]. Fiber is a notable component in mushrooms that plays a role in improving the characteristics of meat analogs. Among the various types of mushrooms, the highest dietary fiber content, namely 137.2 g/kg, is found in *Flamulina velutipes* (enoki mushrooms)[9]. The insoluble fiber component of *Pleurotus eryngii* mushrooms (king oyster mushrooms) has the potential as a hypolipidemic agent, reducing abnormal lipid metabolism, reducing inflammation, and improving intestinal microbiota, which overall plays a role in overcoming obesity[10].

To improve the sensory and freshness quality of meat analogs, several kinds of vegetable oils can be added to the formulation[11], where orange oil shows the best potential in improving the aroma and freshness (succulence) of meat analogs. Adding vegetable oil to the meat analogs formula has been proven to maintain the physicochemical properties and shelf life of meat analogs in frozen storage[5]. This study will improve the formulation of soybean-glucomannan-based meat analogs using mushrooms and vegetable oils. Two types of mushrooms (enoki and king oyster) and two types of vegetable oils (corn oil and orange oil) will be applied in the imitation meat formula, and their effects on the physicochemical characteristics, sensory, and satiety index will be observed.

METHODS

Design, Time, and Place

Experimental research was conducted with a single factor completely randomized design (CRD) with one control and four treatments. The control was in imitation meat from the selected formulation in previous research (Purnawijayanti, et al. 2024), with the addition of oyster mushrooms (*Pleurotus ostreatus*). Four treatments were in the form of meat analogs with a combination of two types of mushrooms, namely enoki (*Flamulina velutipes*) and king oyster (*Pleurotus eryngii*), and two kinds of oil (orange and corn). The research was conducted from June to September 2024. The manufacture of meat analogs, sensory testing, and satiety index were conducted at the Food Technology Laboratory, STIKes Panti Rapih Yogyakarta. In contrast texture, color, and water/oil holding capacity testing were carried out at the Food Engineering Laboratory, Faculty of Agricultural Technology, Gadjah Mada University.

Material

The primary research materials were soy protein isolate (Para Agro) and Konjac glucomannan (d3lynfood). Additional materials are water, wheat gluten (Ric and Bris Fine Food Products), and broth powder (Indofood) which are used in equal amounts in all treatments. Corn oil (Mazola Oil) and orange oil (PT. Dwilab Mandiri Scientific, Bandung) were added as much as 10% in the formula according to previous research[11]. Oyster mushrooms (in the control formula), enoki mushrooms, and king oyster mushrooms were obtained from a local supermarket (Hypermart). Figure 1 shows the tools and materials used in making meat analogs.

Figure 1. Tools and materials for meat analogue processing

Meat Analog Processing

The meat analog formulation refers to the research of Dinani, et al., namely with a water content of approximately 60% and solids of 40%[12], which has been modified[6]. The treatment applied was a combination of oil and mushroom types in the meat analog formulation, namely King oyster mushroom-orange oil (MA_1), King oyster mushroom-corn oil (MA_2), enoki-orange oil (MA_3) and enoki-corn oil (MA_4). The meat analog formula with oyster mushrooms without added oil was used as a control (MA-K). The control formula is selected from previous research (Purnawijayanti et al., 2024). The experiment was repeated three times. The major equipment used was a blender, an electric pasta machine (Wiratech Noodle Maker NOD-888), and cooking equipment as well as texture testing equipment, the TA1 Texture Analyzer (Lloyd-Instruments-AMETEX and Chromameter Konica Minolta CR-400).

Table 1. Formulation of meat analogues with a combination of different types of mushrooms and oils

Bahan	Perlakuan				
	MA-K Control	MA_1 King Oyster-Orange Oil	MA_2 King Oyster-Corn Oil	MA_3 Enoki-Orange Oil	MA_4 Enoki-Corn Oil
Soy Protein Isolate (g)	108	108	108	108	108
Glucomannan (g)	12	12	12	12	12
Wheat Gluten (g)	40	40	40	40	40

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Oyster Mushroom (g)	100	-	-	-	-
King Oyster Mushroom (g)	-	100	100	-	-
Enoki Mushroom (g)	-	-	-	100	100
Aquades (ml)	150	150	150	150	150
Beef Broth (g)	4	4	4	4	4
Orange Oil (ml)	-	16	-	16	-
Corn Oil (ml)	-	-	16	-	16

The procedure for making meat analog includes preparation, mixing, kneading, and extrusion in a pasta machine, molding and steaming, following the procedure from previous studies[6]. Oil is added together with the cut/shredded mushrooms. The procedure is shown in Figure 2.

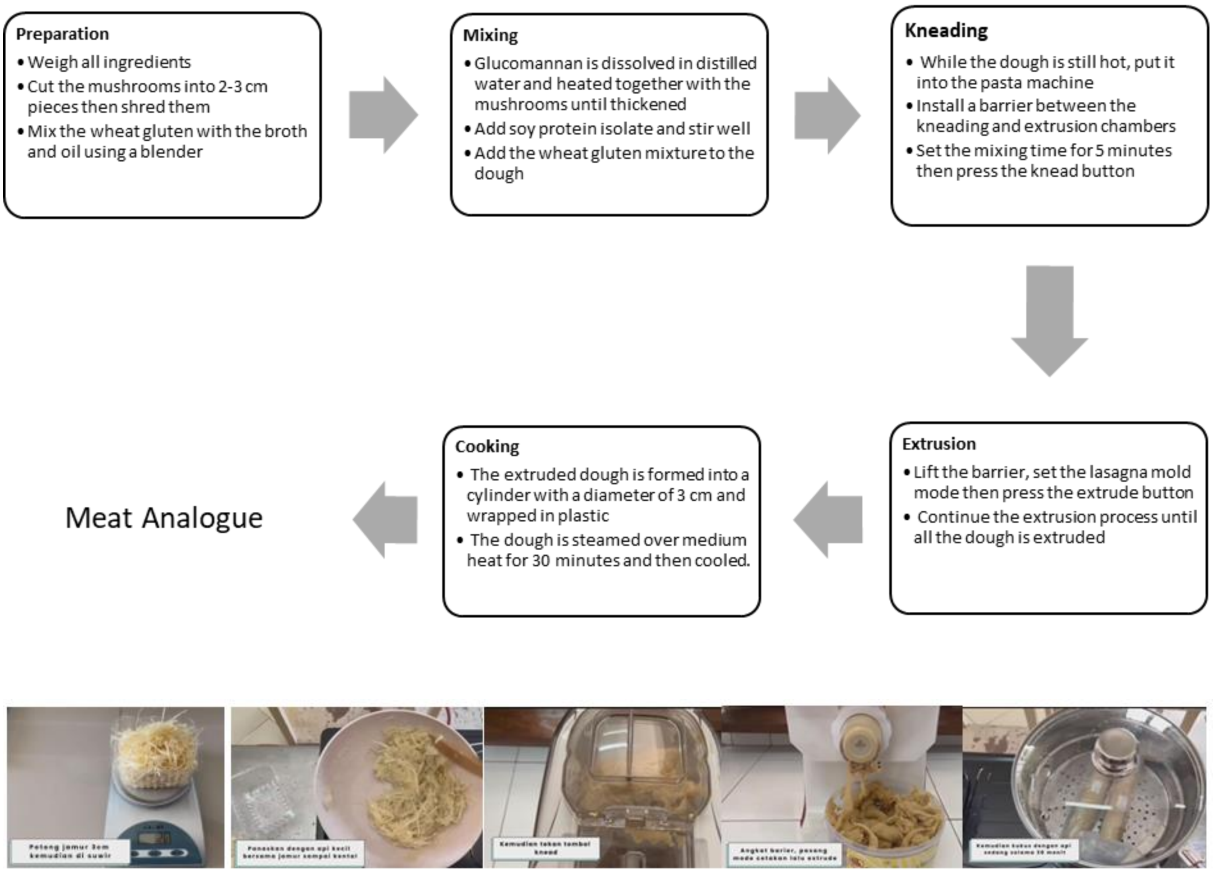

Figure 2. Flowchart of meat analogue manufacturing

Ethical Clearance

The research's certificate of ethical eligibility was obtained through letter number 095.3/FIKES/PL/VII/2024, dated July 25, 2024, issued by the Health Research Ethics Commission, Respati University, Yogyakarta.

Physical Properties Testing

Testing the meat analog's properties physical properties was conducted at the Public Service Faculty of Agricultural Technology, Universitas Gadjah Mada Yogyakarta. The testing was carried out by technicians of the Food Engineering Laboratory, using standard procedures for the texture profile analyzer tool, water/oil holding capacity analysis method, and chromameter tool as follows:

1. Texture Analysis

Texture profile analysis (TPA) was performed using the TA1 Texture Analyzer (Lloyd-Instruments-AMETEX). The meat analog samples were cut from the middle (10 × 10 × 10 mm). Furthermore, a cylindrical probe was prepared. The test conditions were calibrated first. Three replications were performed for each sample. The values of hardness, gumminess, chewiness, springiness, resilience, and cohesiveness were obtained automatically.

2. *Water/Oil Holding Capacity* (WHC dan OHC)

The water and oil binding capacity test of imitation meat was carried out according to the method developed by Chau and Huang[13] as follows:

a. Weigh one gram of sample (a)
b. Sample was vortexed in 10 ml of distilled water (for WHC) or 10 ml of corn oil (for OHC) at 25oC for 1 minute.

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c. The sample was centrifuged at 2200xg for 30 minutes
d. Weigh the wet sedimen (b)
e. The water/oil binding capacity was calculated using the formula:

$$WHC\ or\ OHC = \frac{b-a}{a} x\ 100\%$$

3. Color measurement (color value components include L*(brightness), a*(redness) and b*(yellowness)) values on the sample surface were carried out using a colorimeter (Konica Minolta Inc., Chroma meter CR-400, Japan). The L*, a* and b* values were then used to calculate the browning index (Browning Index - BI) of each imitation meat sample to observe color changes with the addition of mushrooms and vegetable oil. The BI value is determined by the following formula[12]:

$$BI = \frac{100}{0.17} x[(a^*+1.75L^*)/(5.645L^*+a^*-3.012b^*)-0.31]$$

Sensory Evaluation

The sensory evaluation involved 30 panelists of the Nutrition Bachelor's Program student at STIKes Panti Rapih Yogyakarta. Panelists must meet the inclusion criteria, namely being willing to be respondents, not allergic to ingredients of the meat analog formula, being healthy, and not experiencing health problems in the function of the senses. The respondents were selected using a Google form. Panelists who experienced health problems that interfered with the function of the senses at the time of testing were excluded from the test. Sensory testing was carried out using the difference and preference test, by giving a value/score to the sample (scoring difference and preference test). Panelists were asked to assess based on differences in texture and aftertaste characteristics, as well as an assessment based on their preference for the appearance, aroma, taste, and overall preference for the meat analog sample. The assessment score ranged from 1 to 5, with an appearance score of 1 (very unattractive) to 5 (very attractive); an aroma score of 1 (very unpleasant) to 5 (very delicious); a taste score of 1 (very unpleasant) to 5 (very delicious); a texture score of 1 (very unlike meat) to 5 (very like meat); an aftertaste score of 1 (very strong) to 5 (very faint) and an overall liking score of 1 (very dislike) to 5 (very like). Before testing, an explication was given to the panelists to align their perceptions on how to assess.

Satiety Index Test

The satiety index test involved 30 overweight/obese respondents. Before the test, the respondent's anthropometric measurements and body composition were carried out, including total body water, fat mass, muscle mass, percent body mass, basic metabolic rate, waist-hip ratio, and degree of obesity. Respondents underwent the test twice, namely consuming white bread in the first test and processed meat analog in the second test. The serving portions of meat analog and bread contain the same number of calories, 240 calories. Panelists fasted for at least 8 hours/overnight, and the test was carried out in the morning. Panelists gave a satiety score using a satiety scale that had been prepared before consuming the sample, immediately after finishing consuming the sample, and every 30 minutes thereafter until the 180th minute. The data obtained were then plotted on a graph to determine the satiety index, by calculating the area under curve[19]. The satiety score scale 1-10 uses a scale developed by the University Health Services, University of California, Berkeley, as follows:

1. Hungry, no energy, very weak
2. Very hungry, low energy, weak and dizzy
3. Uncomfortably hungry, unfocused, irritable
4. Hungry, stomach growling
5. Starting to feel hungry
6. Satisfied, but could eat a little more
7. Full but not uncomfortable
8. Too full, slightly uncomfortable
9. Overstuffed, very uncomfortable
10. Very full, nauseous

Data Processing and Analysis

Data processing was done using Microsoft Excel, while data analysis was done using SPSS statistical software. Data were analyzed using the Analysis of Variance and the post hoc Duncan Multiple Range Test.

RESULTS AND DISCUSSIONS

Texture Profile

Table 2. Texture profiles of meat analogue with various mushroom and oil formulations

Sample	Hardness Bite (N)	Cohessiveness	Resilience	Springiness	Guminess (N)	Chewiness (N)
MA_K	67.63 ± 7.17b	0.42 ± 0.034ab	0.38 ± 0.031a	0.799 ± 0,024a	29.48 ± 4.88c	24.08 ± 4.45c
MA_1	50.78 ± 2.87a	0.36 ± 0.013a	0.40 ± 0.029a	0.795 ± 0.009a	18.16 ± 1.15a	14.44 ± 0.91a
MA_2	48.09 ± 4.85a	0.38 ± 0.026ab	0.35 ± 0.027a	0.789 ± 0.016a	18.84 ± 2.74ab	15.07 ± 2.39ab
MA_3	52.67 ± 4.83a	0.44 ± 0.019b	0.40 ± 0.015a	0.818 ±0.01a	23.41 ± 2.92abc	19.26 ± 2.55abc
MA_4	62.51 ± 2.12b	0.44 ± 0.021b	0.42 ± 0.020a	0.818 ±0.008a	27.83 ± 1.71bc	22.80 ± 1.49bc
p-value	0.032	0.084	0.41	0.501	0.039	0.050

N = Newtom
Numbers in the same column followed by the same letter indicate no significant difference at α≤0.05

Using enoki mushrooms, king oysters and orange and corn oils in the meat analog formula affected the texture parameters including hardness, gumminess, and chewiness. However, it did not affect cohesiveness, resilience, or springiness. Hardness is related to the maximum force required to compress the meat analog and is defined as the force required to compress the sample using teeth. Hardness is calculated as the maximum force of the first compression. Cohesiveness indicates the strength of the formed tissue and is defined

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as the quantity of the sample that stands together during chewing[14]. Cohesiveness is expressed as the working area during the second compression divided by the working area during the first compression. Resilience is how strong and fast the recovery is and is calculated by dividing the first compression's upstroke energy by the first compression's downstroke energy. Springiness describes the recovery of artificial meat after deformation and defines the extent to which the sample recovers after the second compression to its initial height. Springiness is expressed as the ratio between the height of the sample at the beginning of the second compression and the height at the beginning of the first compression.

Gumminess is a mechanical texture characteristic related to the cohesiveness of a soft product. This is related to the effort required to crush the product in the mouth into a form that is ready to be swallowed and is defined as the product of hardness and cohesiveness. Chewiness is the energy required to chew imitation meat and is the force required to chew the sample before swallowing. Cohesiveness is determined by multiplying gumminess by springiness[15]. The hardness, gumminess, and chewiness values of the four treatment samples tended to decrease compared to the control, with the hardness values of the samples with enoki mushrooms and corn oil not different from the control. The decrease in texture parameter scores also align with Cho's (2023) study[11]. The decrease in hardness, gumminess, and chewiness scores is likely due to the influence of oil which acts as a shortening that inhibits protein hydration during coagulation, and hydrocolloid hydration which inhibits gel formation.

Water-Oil Holding Capacity

Table 3. WHC dan OHC of Meat Analogs Sample

Parameter (%)	Meat Analogue Sample					p-value
	MA_K	MA_1	MA_2	MA_3	MA_4	
Water Holding Capacity	54.28 ± 1.23c	54.81 ± 0.89c	51.42 ± 0.89c	32.72 ± 2.09a	39.28 ± 0.17b	0.00
Oil Holding Capacity	18.37 ± 0.71c	12.90 ± 0.33a	14.58 ± 0.37b	14.84 ± 0.14b	15.16 ± 0.60b	0.00

Numbers in the same line followed by the same letter indicate no significant difference at α≤0.05

Using mushrooms and vegetable oils in the meat analog formula affected the water and oil holding capacity. All combinations of enoki mushrooms and king oyster mushrooms with orange and corn oil tended to cause a decrease in WHC and OHC. The WHC of meat analog with the addition of king oyster mushrooms was not significantly different from the control. The OHC of all samples was lower and significantly different from the control. A material's Water Holding Capacity (WHC) indicates its hydration properties and the amount of water that can be absorbed at the macromolecular level. WHC is known to play an important role in the development of food texture, and higher WHC levels result in less loss during cooking, indicating WHC as a quality index for meat analog. Since fresh raw meat is food with high water content, meat analog should contain higher WHC to mimic the texture, succulence (juiciness), and elasticity of real meat[16]. Water holding capacity (WHC) and oil holding capacity (OHC) are defined as the ability to hold water or oil during force application. They are related to the freshness and deliciousness of meat. Protein is the main component of meat analogs. Therefore protein determines these properties. Water binds the hydrophilic groups of the protein side chains through hydrogen bonds, while oil binds the nonpolar side chains. Thus, WHC and OHC depend on the amino acid composition and protein conformation[15]. In theory, the water holding capacity will also increase with the addition of hydrocolloids[17]. King oyster mushrooms contain highly insoluble fiber composed of cellulose, hemicellulose, lignin, and chitin[10]. The fiber components contain many hydroxyl groups (-OH) which are hydrophilic groups that can increase water absorption and WHC.

Color Profile

Table 4. Color Profile of Meat Analogs

Sample	L*	a*	b*	Browning Index
MA_K	58.52 ± 1.19a	5.49 ± 0.41a	16.53 ± 0.81a	39.77 ± 1.92a
MA_1	60.09 ± 1.49ab	4.59 ± 0.38b	16.92 ± 1.37a	38.31 ± 2.56a
MA_2	61.06 ± 1.13ab	4.40 ± .,07b	17.29 ± 0.09a	38.25 ± 0.86a
MA_3	61.31 ± 1.19b	4.78 ± 0.09b	18.35 ± 0.86b	40.89 ± 0.33a
MA_4	62.58 ± 0.27b	5.55 ± 0.14a	18.26 ± 0.59b	40.67 ± 165a
p-value	0.042	0.001	0.093	0.221

The L* value is the brightness value (– black, + white), a* the redness value (– green, + red), and b* the yellowness value (– blue, + yellow).
Numbers in the same column followed by the same letter indicate no significant difference at α≤0.05

Table 4 shows that all the color scores of the meat analog are positive (+), so the analogous meat color elements are white, red, and yellow. Adding enoki mushrooms or king oysters and corn oil or orange oil affects the L* and a* values but does not affect the b* value and browning index (BI). BI is mainly influenced by the Maillard reaction between the carbonyl group at the end of the polysaccharide reduction and the amino group of the protein[12]. The meat analog formulas in this study all contain amino groups of proteins derived from soy protein isolates, wheat gluten, or mushrooms. Incontrast the carbonyl groups of polysaccharides come from glucomannan or mushrooms. Vegetable oil does not play a role in the Maillard reaction.

Sensory Characteristics

Table 5. Sensory characteristics of meat analogus with various mushroom and vegetable oil formulations

Sample	Appearance	Aroma	Flavour	Texture	*Aftertaste*	Liking
MA_K	4.10 ± 0.19a	3.23 ± 0.10a	3.13 ± 0.16a	3.10 ± 0.18a	3.60 ± 0.16a	3.03 ± 0.16a
MA_1	3.70 ± 0.15a	3.30 ± 0.17a	3.07 ± 0.19a	3.23 ± 0.17a	3.13 ± 0.22a	2.70 ± 0.23a
MA_2	3.67 ± 0.15a	3.30 ± 0.12a	3.10 ± 0.12a	3.10 ± 0.14a	3.37 ± 0.,14a	3.03 ± 0.15a
MA_3	3.87 ± 0.16a	3.83 ± 0.14b	3.23 ± 0.18a	3.63 ± 0.18a	3.20 ± 0.20a	3.03 ± 0.21a
MA_4	4.03 ± 0.16a	3.60 ± 0.15ab	3.30 ± 0.16a	3.43 ± 0.19a	3.60 ± 0.22a	3.07 ± 0.18a
p-value	0.228	0.011	0.840	0.133	0.293	0.608

Numbers in the same column followed by the same letter indicate no significant difference at $\alpha \leq 0.05$
Appearance score: (1) very unattractive, (2) not attractive (3) somewhat attractive (4) attractive (5) very attractive
Aroma score: (1) very unpleasant, (2) not pleasant (3) somewhat pleasant (4) pleasant (5) very pleasant
Flavour score: (1) very bad, (2) bad (3) quite good (4) good (5) very good
Texture score: (1) not very meat-like, (2) not meat-like (3) somewhat meat-like (4) meat-like (5) very meat-like
Aftertaste score: (1) very strong, (2) strong (3) somewhat strong (4) not strong (5) very not strong
Likeability score: (1) dislike very much, (2) dislike (3) somewhat like (4) like (5) like very much

Using enoki and king oyster mushrooms with orange and corn oil only affects the meat analog's aroma but does not affect the appearance, taste, texture, aftertaste, or overall liking. The appearance of meat analog with the addition of enoki mushrooms and corn oil (MA-4) has an attractive score due to the control. The appearance scores of other samples are between slightly attractive (3) and attractive (4). The appearance of all meat analog samples can be seen in Figure 3. These results were in line with the results of the browning index test that showed no effect of using enoki mushrooms and king oyster mushrooms with orange and corn oil in the meat analogs formula on the browning index.

Figure 3. The appearance of meat analogue with various variations of mushroom and vegetable oil formulations

The aroma score of meat analogs with mushrooms and oil tended to increase. A significant increase in the score occurred in samples with the use of enoki mushrooms, both those combined with orange oil and corn oil. All samples had an aroma between slightly pleasant and pleasant (scores between 3-4), with a score of 3.6-3.83 in samples with the addition of enoki mushrooms compared to control samples and samples with the addition of king oyster mushrooms with scores between 3.23 - 3.30. Enoki mushrooms (*Flamulina velutipes*) contain the major aroma compound hexanal[9]. Hexanal is a C-6 aldehyde, a green-scented molecule characteristic of the taste of fruits, vegetables, and green leaves. Hexanal is a high-value product that is widely used by the aroma industry[18]. The flavor scores of the control meat analog and samples with mushrooms and oil were slightly pleasant category (3.07 - 3.30). The texture scores of the control and meat analog samples were somewhat meat-like, with the texture scores of samples with the addition of enoki mushrooms tending to increase closer to resembling meat (3.43-3.63) compared to other samples and the control with texture scores between 3.10 - 3.23. The aftertaste scores tended to decrease with the use of mushrooms and oil with a rather strong aftertaste (scores 3.13 - 3.37), except for samples with the use of enoki mushrooms and corn oil whose aftertaste scores were the same as the control (3.60, between rather strong and faint). There was no difference in the overall liking of the panelists for the meat analog samples, with the category of rather liking (score 3), with the smallest score in the sample with the addition of king oyster mushrooms and orange oil (score 2.7, between dislike and rather liking).

Satiety Index

Table 6. Characteristics of respondents to the satiety index test

Characteristics	Score*
Age (year)	30.38 ± 12.20
Weight (kg)	78.22 ± 10.18
Height (cm)	159.11 ± 6.86
Body Mass Index (kg/m^2)	30.69 ± 2.80

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Characteristics	Score*
Percent Body Fat (%)	43.82 ± 6.46
Fat Mass (kg)	34.24 ± 6.58
Skeletal Muscle Mass (kg)	24.18 ± 4.85
Total Body Water (kg)	32.26 ± 5.76
Basal Metabolism Rate (kCal)	1319,.6 ± 170,18
Waist to Hip Ratio	0.94 ± 0.03
Obesity Degree (%)	144.76 ± 13.53

*Average of 30 respondents

Respondents were 30 students and employees of Panti Rapih Health Sciences College Yogyakarta aged 19-56 years. Of the 30 respondents, 14 were in the overweight category (body mass index/BMI 25 -29.9 kg/m2) and 16 were obese (BMI ≥ 30 kg/m2). All respondents had a waist-to-hip ratio ≥0.90. The degree of obesity of the respondents varied from 126 to 169%, with an average of 144.76%. The normal degree of obesity is in the range of 90-110%.

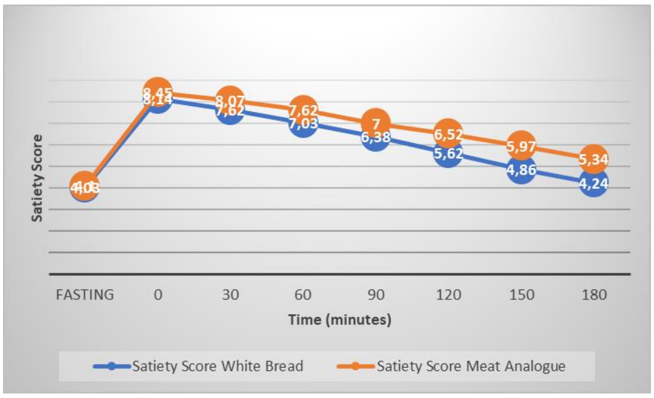

Figure 4. Graph of respondents' satiety scores against time before and after consumption (minutes)

In the satiety index test, the MA-4 sample was used, namely a meat analog with enoki mushrooms and corn oil. Sample selection was based on the sensory testing result where the MA-4 sample had a relatively better sensory characteristic score than other samples. The calorie value test using the bomb calorimeter method showed that in 100 grams of the MA-4 sample, there were 249.07 calories. The satiety index was determined by comparing the area under the sample curve and the area under the standard food curve (white bread). The satiety index was expressed in percent. The test results showed that the area under the meat analog curve was 48.35 and under the bread curve was 43.78. Thus, the satiety index of the MA_4 sample was 110.4%. The satiety index of more than 100% indicates that the meat analog provides a sensation of fullness longer than the control (white bread). Foods with a high satiety index can suppress hunger as they are beneficial in treating obesity[19]. Foods that produce a strong feeling of fullness have clear benefits for weight management. The satiety index of a food depends on the amount of protein, carbohydrate, fat, and fiber it contains[20].

The strength of this study are that it can produce meat analog products with better texture characteristics and sensory organoleptic quality and a satiety index of more than 100%, which can be applied in obesity interventions. The limitation of the research is that the nutritional composition test has not been done, so it is not yet possible to analyze what nutrients play a role in determining the meat analog satiety index. Further research is needed to test *in vivo* meat analog products *in vivo* to study their effectiveness in improving obesity intervention parameters.

CONCLUSIONS

King oyster, enoki mushrooms, corn and orange oil, can be used in soy and glucomannan-based meat analog formulations. The use of mushrooms and vegetable oil in the formulation affects the texture characteristics of hardness, gumminess, organoleptic characteristics of aroma, and water and oil holding capacity. However it does not affect the texture characteristics of cohesiveness, resilience, springiness, organoleptic characteristics of appearance, taste, texture, aftertaste and overall liking and browning index. The meat analog formula with enoki mushrooms and corn oil tends to improve its organoleptic quality. The satiety index of meat analog with the addition of enoki mushrooms and corn oil is 110.4%, showing that meat analog is suitable for obesity intervention.

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CONFLICT OF INTEREST AND FUNDING DISCLOSURE

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AUTHOR CONTRIBUTIONS

HAP: development of ideas and concepts, responsible for research activities, drafting articles; VIP: formulation and product manufacturing, data analysis; MIE: ethical clearance management, sensory testing, and article editing.

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