

## Physical and Proximate Analysis of Instant Vegan Baby Complementary Foods by Freeze Drying Method with Variations of Tomato, Mushroom, and Seaweed

### Analisis Fisik dan Proksimat MPASI Instan Vegan Metode Freeze Drying dengan Variasi Tomat, Jamur, dan Rumput Laut

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**Abstract:** The 2023 SKI data shows that conventional complementary feeding is still inappropriate for the 6-11 month age group. Foods high in sugar still make up a large part of commercial complementary foods. The purpose of this study was to determine the effects of cold-processed vegan instant complementary foods made from local ingredients, including various types of tomatoes, mushrooms, and seaweed, on infants aged 9-11 months. The study utilized experimental methods with physical test parameters such as water solubility, water absorption, viscosity, and color, as well as proximate tests such as fat content, protein content, water content, ash content, carbohydrate content, and total calories. The research was conducted with one sampling and three tests. The addition of tomatoes, mushrooms, and nori had a significant effect ( $p < 0.050$ ) on protein content ( $p = 0.027$ ), carbohydrate content ( $p = 0.001$ ), total calories ( $p = 0.000$ ), absorbency ( $p = 0.030$ ), viscosity ( $p = 0.000$ ), and color  $a^*$  ( $p = 0.003$ ) and color  $b^*$  ( $p = 0.050$ ). The addition of tomato, mushroom, and nori did not have a significant effect ( $p > 0.005$ ) on fat content ( $p = 0.066$ ), ash content ( $p = 0.051$ ), water content ( $p = 0.301$ ), solubility ( $p = 0.107$ ), and  $L^*$  color ( $p = 0.422$ ). The only product that met the standards and was the best formulation was the tomato variety.

**Key word:** Baby food, freeze drying, instant, local food, vegan

## 1. INTRODUCTION

Complementary Foods for Breast Milk (in Indonesian called MPASI) are foods that have a solid, semi-solid, or soft texture, whether prepared traditionally (at home or from homemade products) or commercially produced. When a baby is 9-11 months old, the daily calorie requirement according to Heimburger's formula (2006) is 740.8 kcal for boys and 678.5 kcal for girls. Breast milk supply only contributes 379 kcal/day. Therefore, the daily calorie requirement for a 9-11 month old baby from baby food is around 300 kcal. (1) In Indonesia, both local and commercial baby food have their own downsides.

According to SKI (Survei Kesehatan Indonesia) 2023 data, complementary feeding for the 6-11 month age group is still dominated by commercial formula porridge (35.6%), biscuits (29.3%), flour/strained porridge (24.4%), pureed fruit (36.2%), and rice porridge (36.5%). Meanwhile, commercial baby food has a major problem: excessive sugar content. Based on research, 12.3% of commercial biscuit products and only 47.7%

of powdered products have sufficient sugar content. (2) Baby food with the right formula and texture, durability and long-lasting, and local ingredients are needed because the age of 9-11 months is the most crucial period for reducing stunting. (3; 4)

One of the best preservation methods for baby food is freeze-drying. This preservation method is based on the principle of directly sublimating water from the solid phase of ice into vapor by passing through a melting phase. (5) Benefits of freeze-drying include a crunchy texture, stability and durability, maintained organoleptic and nutritional values, ease of transport and storage, and the ability to rehydrate to its original product. (6)

Baby's complementary feeding with local ingredients was chosen to suit Indonesian tastes. White sweet potatoes were chosen as a carbohydrate source because they have 123 kcal of calories per 100 grams and 28.79% carbohydrates. (7) Moringa oleifera was added because it contains protein (28.25%), 2241.19 mg of calcium, 36.91 mg of iron, and 28.03 mg of magnesium. Furthermore, moringa leaves has also been shown to increase BMI in children. (8; 9) Carrots contain 3.78 mcg of carotene per 100 grams, which is a good source of antioxidants for babies. (10) Broccoli contain vitamins C, K, and A. Minerals found in broccoli include potassium, calcium, and iron, which help the body act as antioxidants that reduce inflammation.

Soy Protein Isolate is a globular protein found in soybeans and has functions such as improving food texture, acting as a binding force, and increasing the prebiotic and probiotic activity of food. (11) The fat used in baby food is VCO (Virgin Coconut Oil), which contains vitamin E, phenols, sterols, and natural lauric acid, which have been proven to provide positive benefits when given as a food ingredient to babies. (12; 13) Lecithin from soy is also used as an emulsifying agent due to the presence of oil in the formula. (14)

Each formulation will be supplemented with tomatoes (*Solanum lycopersicum*), oyster mushrooms (*Pleurotus ostreatus*), and seaweed (*Porphyra yezoensis*). This addition is made because tomatoes, mushrooms, and seaweed have a high glutamate content, which is expected to improve organoleptic value, especially flavor. (15-18)

The baby food formulation will be tested with several feasibility tests, including physical tests such as viscosity, color spectrum, solubility, and water absorption. The second test is a complete proximate test consisting of water content, ash content, protein content, fat content, carbohydrate content, and total calorie analysis. All test results will be compared with the applicable standards for baby food, specifically SNI 01-711.1 of 2005 and BPOM no. 24 of 2020, as well as other standards found in the literature for instant baby food in the form of rusk or liquefied solids.

## **2. METHODS**

### **Study Design**

This research is an experimental study design using Complete Randomized Design (CRD) with one treatment of adding variation of tomato, mushroom, and seaweed as flavour. This research was conducted with one sampling and each treatment was tested in triplicate.

	Weight of ingredients (g)			Percentage of ingredients (%)		
	Tomato	Mushroom	Seaweed	Tomato	Mushroom	Seaweed
<b>White sweet potato</b>	500	500	500	58,48	61,35	63.69
<b>Moringa</b>	40	40	40	5,26	5,52	5.73
<b>Broccoli</b>	25	25	25	3,51	3,68	3.82
<b>Soy Isolate</b>	60	60	60	5,85	6,13	6.37
<b>Carrots</b>	100	100	100	9,36	9,82	10.19
<b>VCO</b>	45	45	45	5,26	5,52	5.73
<b>Tomatoes</b>	100			11,70		
<b>Mushrooms</b>		60			7,36	
<b>Seaweed</b>			30			3.82
<b>Soy lecithin</b>	5	5	5	0,58	0,61	0.64
<b>Total</b>	875	835	805	100%	100%	100%

\*Additional variations are made after the staple ingredients meet the nutritional needs of children aged 9-11 months.

This research was conducted at PT. Inasentra Unisatya, Bogor, West Java, from preliminary research (March-May 2025) to determine the appropriate freeze drying machine settings and determine the formulation with balanced nutrition according to the guidelines to the main research (June-August 2025). Tests were conducted at the GIS Laboratory, Semarang, Central Java, the Instrument Laboratory, Nutrition Study Program, Faculty of Medicine, Diponegoro University, and the Chemistry Laboratory, Nutrition Study Program, Faculty of Medicine, Diponegoro University.

## **Research Tools and Materials**

### **Baby Food Making**

All wet ingredients, namely white sweet potatoes, carrots, broccoli, tomatoes, and mushrooms, come from Bekasi City. White sweet potatoes are processed a maximum of 1 week after the arrival of fresh goods. Carrots, broccoli, moringa, tomatoes, and raw oyster mushrooms are stored in a chiller with a temperature of 2-8°C. All ingredients are stored and processed at the labskill PT. Inasentra Unisatya, Bogor.

The selected white potatoes (*Ipomoea batatas*) are grade II or I SNI 4493:2023. Moringa oleifera leaves were fresh, 1 cm in size, and perfectly green, without drying. The carrots used are Berastagi carrots (*Daucus carota L.*). They have a sweeter taste and meet SNI 3163-2014 standards for super-class carrots. The broccoli (*Brassica oleracea var. Italica*) is selected using horticultural standards. The broccoli used is the flower part with minimal stems or only the base of the flower, with the flower color must be green and firm.

Soy protein isolate that used already BPOM dan HALAL aproved with 90.08% protein and 6.42% moisture. ash content 5.4%, and free from *Salmonella* and *E. Coli*. The VCO stored at room temperature of 24°C to prevent freezing , air permeability, and in tightly closed bottles. Lecithin used as an emulsifier. The lecithin used is made from soybeans.

As additional flavor, each formula has different additions in the form of tomatoes, mushrooms, and unsalted seaweed. The tomatoes used are regular red/market tomatoes (*Solanum lycopersicum*). The mushrooms used are oyster mushrooms (*Pleurotus ostreatus*). The seaweed (*Porphyra yezoensis*) used is seaweed that has not been given additional salt and has been dried.

Blast freezing is set for 180 minutes for a temperature of  $-40^{\circ}\text{C}$  and 1470 minutes for vacuum freezing with the highest temperature being  $50^{\circ}\text{C}$  for 630 with a pressure of 50 Pa. When the second compressor was on, the recorded pressure data was 17.5 psi *low pressure* and 210 psi *high pressure* for *Compressor 1* and 30 psi *low pressure* and 250 psi *high pressure* for *Compressor 2*. The recorded pressure for the oil pump was 0.06 MPa.

### Physical Test

The water solubility of dried MPASI was tested using a test developed by Fardiaz. (19) The solubility analysis was carried out using 0.75 grams of baby food and dissolved in 100 ml of distilled water. The oven used was the ESCO brand with the OFE-54-8 model.

The water absorption capacity of dried baby food was tested using a test developed by Fardiaz. (19) Weigh 1 gram of baby food product in an analytical balance along with the centrifuge tube. Add 10 ml of distilled water. Vortex the MPASI mixture with water for 2 minutes or until mixed, then centrifuge for 25 minutes at 300 rpm. Separate the supernatant with a micropipette and then weigh the tube into an analytical balance.

The viscosity test for MPASI was conducted using a Biodave BDV-9S digital viscometer. The baby food dissolved in distilled water at a temperature of  $80^{\circ}\text{C}$  until it reached a volume of 500 mL. The data will be generated in the form of viscosity (mPa.s) and a confidence percentage (%) between 15 – 85%.

Color analysis is done using colorimeter. The operation of the DS 200 *colorimetric spectrophotometer* is based on the factory standard operating manual contained in the tool box. The data generated in the format of numbers  $L^*$  (for brightness level),  $a^*$  (for red to green), and  $b^*$  (for yellow to blue spectrum).

### Proximate Test

The moisture or water content test using SNI 2354.2:2015. Sample will be placed in each ceramic container as much as 10 grams. Ash content testing is based on SNI 2354:2010. The baby food sample test use grinded 2 grams of sample with a mortar and then placing it in an oven. The fat content test of vegan baby food is based on SNI 2354-3:2017. The test used 5 gram sample, wrapping it in filter paper, then staple it tightly closed. The filter paper used is Japanese filter paper with 47  $\mu\text{m}$  filtration.

The protein content test of baby food is based on SNI 01.2354-4:2006 . The test use 2 grams off samples, 2 catalyst tablets derived from 7.0 grams of  $\text{K}_2\text{SO}_4$  and 0.83  $\text{CuSO}_4$ , 15 ml of concentrated  $\text{H}_2\text{SO}_4$  (95-97%) and 3 ml of  $\text{H}_2\text{O}_2$  pa (30-35%). For flasking, use erlenmeyer containing 25 ml of a 4%  $\text{H}_3\text{BO}_3$ , 50 ml of distilled water to the digestion flask, 50 ml of sodium hydroxide-thiosulfate solution. The distillate will be distilled with standardized 0.2 N HCl. Carbohydrate content and total calories is analyzed by subtraction, which this method only need calculator, pen, and paper.

### Research Procedure

The research was conducted by manufacturing the product first. Processing begins with brushing the white sweet potato skin under running water, peeling, soaking to remove the sap, and steaming. The steamed sweet potatoes are mashed with a potato masher. The moringa leaves were thoroughly washed under running water, weighed, and then blanched for 2-3 minutes in boiling water. The cooked Moringa leaves were finely

chopped. The carrots are cleaned, cut into smaller pieces, blanched, and then crushed with a chopper. The broccoli is first cut, soaked in citric acid and salt before being blanched, then finely chopped. All ingredients are mixed together until evenly distributed. The isolate is unprocessed and simply added directly to the dough. For the lecithin and oil is mixed with heat before added to the dough.

Tomato processed by washing, cutting, blanching, before finally being finely chopped with the seeds. The mushroom these mushrooms will be washed thoroughly with water mixed with citric acid, blanched, then cut into small pieces. The seaweed processed by only adding hot water and chopped. After being mixed and molded, the results will be put into a freeze drying machine.

Once the baby food samples were completed and packaged, the ingredients were tested in the laboratory for physical and proximate testing. The solubility and water absorption tests were based on tests developed by Fardiaz. The viscosity test used a digital viscometer (Brookfield). The color test was performed using a spectrophotometer. The water content was determined using the oven method (SNI 2354.2:2015), the ash content using the oven method (SNI 2354:2010). The fat content was determined using the Soxhlet method (SNI 2354-3:2017). The protein content was measured using the Kjeldahl method (SNI 01.2354-4:2006). The carbohydrate content was measured using the by-difference method. Then, the calorie test used kkal/gram counting. All the test was performed in triplicate.

### Statistical Analysis

Data processing was performed using SPSS version 26.0 by editing, coding, and entering data into the software. Univariate data analysis was performed using Shapiro Wilk to test for normality because all data were <30 samples. Bivariate analysis was used to determine the significant effect of differences in the addition of ingredients in the formulation of the three baby food. Normally distributed data used One Way ANOVA, while non-normally distributed data used the Kruskal-Wallis test.

In this study, physical tests in the form of solubility, absorption, and viscosity as well as proximate tests in the form of carbohydrate content and total calorie count used One Way ANOVA because normality analysis with Shapiro Wilk showed normally distributed data results. Meanwhile, protein content, fat content, ash content, water content, and color analysis used Kruskal-Wallis. This study used a 95% confidence interval with a significance level of 0.05. The test was continued to further analysis when the One Way ANOVA and Kruskal-Wallis tests gave a significant effect. The parameters that carried out further tests were protein content with pairwise, carbohydrate content with Tukey, total calories with Tukey, viscosity with Duncan, and color test with Duncan.

## 3. RESULTS

### Physical Result

Parameter	Data mean ± SD / Median (min-max)			p-value
	Tomato	Mushroom	Seaweed	
<b>Solubility (%)</b>	26,77 ± 3,38	29,43 ± 2,75	33,47 ± 5,90	0,223*
<b>Absorption capacity (%)</b>	507,12 ± 4,74 <sup>a</sup>	564,34 ± 31,51 <sup>b</sup>	490,80 ± 31,48 <sup>a</sup>	0,030**

Parameter	Data mean ± SD / Median (min-max)			p-value
	Tomato	Mushroom	Seaweed	
<b>Viscosity (mPa.s)</b>	7474,67 ± 492,21 <sup>a</sup>	4205,20 ± 127,44 <sup>b</sup>	911,03 ± 207,85 <sup>c</sup>	0,000**
<b>Color L* Brightness spectrum</b>	77,66 (58,91-83,33)	74,32 (69,70-83,72)	74,26 (53,13-81,70)	0,369***
<b>Color a* Red-green spectrum</b>	3,88 (1,29-10,41) <sup>a</sup>	1,22 (-2,71-10,60) <sup>ab</sup>	0,82 (5,65-4,56) <sup>b</sup>	0,003***
<b>Color b* Yellow-blue spectrum</b>	37,51 (28,86-43,01) <sup>ab</sup>	37,28 (32,47-47,76) <sup>b</sup>	32,25 (18,66-44,89) <sup>a</sup>	0,050***

\*:Kruskall Wallis Test, \*\*:Kruskall Wallis test with pairwise follow-up test, \*\*\*:One Way Anova test with Tukey's follow-up test, a,b:similar letter notation, no real difference at the advanced test level.

The water solubility test for baby complementary food is conducted to determine the ability of dried baby food to disperse in water. The ANOVA test analysis showed that the data showed a difference with a p-value > 0.05, namely 0.223. Therefore, baby food tomatoes, mushrooms, and seaweed were not significantly.

A physical test of water absorption capacity for baby food was conducted to determine the ability of baby food to hold water to its highest point. The ANOVA test analysis showed that the data showed a difference with a p.value < 0.05 (0.030), so that baby food variations were significantly different. The further test used was the Duncan test. This test revealed that tomato and nori baby food had insignificant water absorption, while both were significantly different from oyster mushroom baby food.

The physical viscosity test for baby food was conducted to determine the viscosity of baby food so that it can be adjusted to the needs and eating abilities of infants. The ANOVA test analysis showed that the data showed differences with a p.value < 0.05, namely 0.000. The results of the Duncan test show that the viscosity for baby food tomatoes, mushrooms, and seaweed are different from each other.

The color test was conducted with the aim of determining the spectrum for baby food variants of tomatoes, mushrooms, and seaweed. The results of the Kruskal Wallis test for color analysis showed that baby food for L\* had an even color distribution (not significantly different) with a significance of 0.369, the color character a\* was significantly different with a significance of 0.004, and the color character b\* was significantly different with a significance of 0.050.

The color test data shows that all variations of baby food have the same brightness with L\* having an average of 72.11 which indicates that baby food has a tendency towards white (bright) color. The a\* character which is a red to green parameter. baby food has an average a\* composition of 2.16 which indicates that baby food has a tendency towards red because it is more than 0. The baby food that has the greenest color is seaweed variation with an average of 0.1, followed by mushrooms with an average of 2.45, and tomatoes with an average of 4.1. Furthermore, for the b\* character which symbolizes the tendency towards yellow to blue color. The most yellow baby food is mushrooms with an average of 39.08, followed by tomatoes with a value of 36.64, then finally with seaweed which has an average of 31.33.

## Proximate Result

Parameter	Data mean $\pm$ SD / Median (min-max)			p-value
	Tomato	Mushroom	Seaweed	
Protein content (%)	13,98(13,92-14,10) <sup>a</sup>	12,09 (12,02-12,12) <sup>ab</sup>	11,11 (11,05-11,28) <sup>b</sup>	0,027**
Fat content (%)	21,26 (21,21-21,54)	22,70 (22,54-22,81)	22,61 (22,40-22,95)	0,066*
Ash content (%)	2,77 (2,71-2,78)	3,11 (3,07-3,14)	2,79 (2,73-2,83)	0,051*
Water content (%)	2,99 (2,10-3,02)	2,80 (2,78- 2,82)	2,92 (2,87-2,95)	0,301*
Carbohydrate content (%)	58,87 $\pm$ 0,23 <sup>a</sup>	59,33 $\pm$ 0,14 <sup>a</sup>	60,50 $\pm$ 0,39 <sup>b</sup>	0,001***
Total calories (%)	483,51 $\pm$ 0,94 <sup>a</sup>	489,79 $\pm$ 0,74 <sup>b</sup>	490,47 $\pm$ 1,33 <sup>b</sup>	0,000***

\*:Kruskall Wallis Test, \*\*:Kruskall Wallis test with pairwise follow-up test, \*\*\*:One Way Anova test with Tukey's follow-up test, a,b:similar letter notation, no real difference at the advanced test level.

The water content test is one of the proximate test parameters used to identify the remaining free water content in baby food. The Kruskal Wallis test analysis showed that the data showed no difference with a p-value > 0.05, namely 0.301. The ash content test is one of the proximate test parameters used to identify the mineral content in baby food. The Kruskal Wallis test analysis showed that the data showed no difference with a p-value > 0.05, namely 0.051. The fat content test is one of the proximate test parameters used to identify the content of organic compounds that are insoluble in water but soluble in organic solvents in baby food. The Kruskal Wallis test analysis showed that the data showed no difference with a p-value > 0.05, namely 0.066.

The protein content test is one of the proximate test parameters used to identify the amount of nitrogen in baby food. The Kruskal Wallis test analysis showed that the data showed a difference with a p.value <0.05, namely 0.027. Through pairwise comparison, data was obtained that the significant protein content was the protein content of tomato with seaweed variation, while the difference between tomato with mushroom and mushroom with seaweed variation was not significant.

The ANOVA test analysis of carbohydrates showed that the data showed differences with a p.value <0.05, namely 0.001. The results of the Tukey test show that the carbohydrate levels for baby food tomatoes, mushrooms, and seaweed are in two different columns, indicating that the carbohydrate levels for seaweed variation are different from the others.

The calorie content test is one of the proximate test parameters used to determine the energy content per 100 grams of baby food ingredients. The ANOVA test analysis showed that the data showed differences with a p.value <0.05, namely 0.000. The results of the Tukey test show that the calories of tomatoes variation are different from the others.

## 4. DISCUSSION

### Physical Test

#### Water Solubility

The water solubility of baby food variations of tomatoes, mushrooms, and seaweed did not differ significantly and had an average of  $29.89 \pm 4.69$  across all trials. Compared with the solubility research for commercial baby food of 18-23% (20), the solubility level of vegan

baby food still does not meet the standard. The baby food closest to the standard is the mushroom variation with a solubility of  $26.77 \pm 3.38\%$ . The solubility of baby food is important to maintain according to the standard because it plays a role in the baby's mouthfeel on the rough, soft, or even gritty texture of the food consumed. (19)

The solubility of baby food can be influenced by the main ingredient, namely white sweet potato, the baby food processing method itself, the water content, and the fiber content of additional ingredients. White sweet potato contains starch with amylose and amylopectin, which can degrade during cooking, freeze-drying, and cooking. Starch breakdown can increase the solubility of baby food products. (20), water content is at odds with water solubility. (21)

### **Water Absorption Capacity**

The average water absorption capacity of baby food across all trials was  $520.75 \pm 40.25\%$ . Converted to 1 gram of material, 1 gram can hold a maximum of 5.2 grams of water. The water absorption capacity of all instant baby food products variations met the standard, at 3.60 to 6.20 grams per gram (3.60-6.20 g/g).

Absorption capacity is influenced by several factors, specifically starch dispersion, water content, protein content, and fat content. The higher the starch damage, the higher the starch dispersion in water. Baby food that undergoes the process of crushing/mashing sweet potatoes and cooking has a high probability of starch dispersion. Then, in contrast to solubility, the absorption index will be in line with the increasing water content of baby food. (22) Protein is hydrophilic, so the protein content of baby food ranging from 11.05 to 14.1% supports water absorption. (23) Meanwhile, fat is hydrophobic so the higher the fat content, the lower the ability of baby food to absorb water. (24) The fat content in baby food has an average of  $22.22 \pm 0.69\%$  and is significant between formulations.

The water absorption capacity of baby food variations of tomatoes, mushrooms, and seaweed differs significantly. This difference is particularly significant for baby food made with oyster mushrooms. Mushrooms contain a special type of fiber, chitin, which can bind water more effectively. Furthermore, mushrooms contain hemicellulose and pectin, which strengthen their water-binding capacity and reduce the density of the material. (25-27)

### **Viscosity**

Tests showed that the viscosity of tomatoes ranged from 7474.67 mPa, the viscosity of mushrooms ranged from 4205.2 mPa, and the viscosity of seaweed variations ranged from 911.03. Meanwhile, the viscosity standard for baby porridge is 1000-3000 mPa, with the ideal figure being 1400 mPa. This means that none of the vegan baby food met the standard, with the closest variation being the seaweed variation.

The viscosity of the tomato, mushroom, and seaweed variations of baby food differed significantly. This indicates that each recipe produced a different viscosity even when treated the same, from the weight of the ingredients used to the amount and temperature of the water used. Normality measurements of the percentages of the ingredients showed no significant differences, indicating that the difference in viscosity stems entirely from the types of variations added: tomatoes, mushrooms, and seaweed.

The concentration, type, and swelling ability of the protein, or its ability to expand from the added ingredients, all influence viscosity. Furthermore, larger proteins or proteins that

have undergone denaturation will increase this (28) In line with protein content, the order of viscosity, from highest to lowest, is tomatoes (11.70%), oyster mushrooms (7.36%), and then seaweed (3.82%).

## **Color**

The  $a^*$ ,  $b^*$ , and  $L^*$  color test data show differences due to the color of the added ingredients, the percentage of ingredients, and the freeze-drying process itself. Although freeze-drying is claimed to be the best method for preserving product color, color changes can still occur due to water loss. (5; 29)

Tomatoes have an average brightness of  $L^*=43.29$  (30), fresh oyster mushrooms have an average brightness of  $L^*=80-85$  and those dried for 20 minutes have a brightness of  $L^*=62.86$  (31; 32), while seaweed has an average brightness of  $L^*=35.17$  (33). This shows a discrepancy because tomatoes have a lower brightness than mushrooms and the addition of the most ingredients actually becomes the brightest formulation ( $L^*=77.66$ ). This difference can be caused by the blanching process being too long resulting in color fading due to the loss of beta-carotene and the freeze-drying process. Mushrooms have a change in brightness because mushrooms are preserved by heating so that polyphenol enzymes react. Seaweed is able to maintain its color because it is processed by chopping (not completely destroyed) and spread throughout the baby food. <sup>36-39</sup>

The color test for the  $a^*$  character shows that baby food of all variants is in a faint red color because its position in the color palette is almost exactly between red and green, the furthest is the tomato variation with a number of 4.1. Tomatoes have an average magenta color  $a^* = 20.36$ , oyster mushrooms dried for 20 minutes have a value of  $a^* = 2.65$ , while seaweed has an average magenta color  $a^* = -0.58$ . This is in line with the results of research showing that the tomato variety is the reddest variation, followed by oyster mushrooms, and seaweed is the greenest. (33)

Then, the  $b^*$  character which indicates the degree of difference from yellow to blue shows that the yellowest baby food is the mushroom variety with a  $b^*$  value of 39.08 and the bluest variation is seaweed with a  $b^*$  value of 31.33. (34) Tomatoes have an average blue-yellow color of  $b^* = 27.79$ , oyster mushrooms dried for 20 minutes have a  $b^*$  value of 20.73, while seaweed has an average blue-yellow color of  $b^* = 4.08$ . This is somewhat in line with the results of research showing that tomatoes have the highest tendency for yellow color, followed by oyster mushrooms, then seaweed has the lowest tendency for yellow color. All results are around  $b^* = 32.25-37.51$  due to the influence of the color of blanched yellow sweet potatoes which is at  $b^* = 23.4$  (35) and other raw materials in baby food which are yellow, namely carrots with a  $b^*$  value of 69 in the same amount. (36)

## **Proximate Test**

### **Water Content**

Baby food variations of tomatoes, mushrooms, and seaweed had water content that did not differ significantly, namely  $2.80 \pm 0.28\%$ . This means that the water content of vegan baby food has met the BPOM standard number 24 of 2020 which discusses the water content limit for powdered or biscuit-shaped ingredients of a maximum of 5% (w/w) and SNI 01-711.1 of 2005 for baby food products in the form of instant powder at 4% (w/w).

The pressure, temperature, and vacuum time during the freeze-drying process affect the resulting baby food. (37) According to preliminary research, all products met the established moisture content standards because the freeze-drying process was adapted to vegan baby food products. Then Ripe red tomatoes have a water content of up to 94% (w/w). Then, the tomatoes are processed using the blanching method. first so that it has a raw-cooked weight change of 85%. Oyster mushrooms have a water content of 86-87.5% (w/w). (32) Then, the seaweed used has a water content of >95%. Each water content in this material consists of free water and bound water. Free water is the water in the food material, while bound water is the water content bound to molecules in the food material such as fiber, capillaries, and others. From this study, it was shown that the water content in tomatoes, mushrooms, and seaweed that had been soaked was dominated by free water so that it could be sucked up by vacuum freeze drying . (38)

### **Ash Content**

The ash content test showed no significant difference of the tomato, mushroom, and seaweed variants of baby food. The average ash content was  $2.88 \pm 0.17\%$  (w/w). According to SNI 01-711.1 of 2005, all vegan baby products still meet the standard for ash content, which is a maximum of 3.5% (w/w).

Mineral limits in baby food are important because minerals can cause the body to experience deficiencies or toxicity. (24) The study found the highest results in baby mushrooms with a content of  $3.1067 \pm 0.0351$ . This is in line with the mineral content of mushrooms, namely calcium, potassium, phosphorus, sodium, and iron, reaching 3.4-18.2 grams. Tomatoes, which are given in the largest amount, actually have the lowest ash content because they are dominated by potassium (235 mg/100 grams of material) with other minerals detected being sodium in small amounts (5 mg/100 grams of material). (39) Seaweed has a mineral content that is dominated by sodium because it comes from the sea. Other minerals contained in seaweed are calcium and iodine. (40)The mineral content can even reach 50% of the dry weight of the material. (41)

### **Fat Content**

The fat content of vegan baby food did not differ significantly and had an average of  $22.24 \pm 0.69\%$  (w/w). This indicates that according to SNI 01-7111.1 of 2005, the fat content exceeds the total fat requirement of under 15 grams/100 grams of material. The largest deviation from the standard was 5.62 grams from the seaweed variation and the smallest deviation was 4.39 from the tomato variation. Meanwhile, according to BPOM No. 24 of 2020, the only formula that met the standard was the tomato formulation with an average fat content of 4.41 grams/100 kcal of material.

The main source of fat in vegan baby food is VCO ( virgin coconut oil ) added with an emulsifier. The main error in this study was the unaccounted fat from soy lecithin. Lecithin can serve as a fat substitute, but for this study, data on the fat in soy lecithin was not available and was not taken into account. (42)

The fat content of the instant vegan baby food for the tomato variation had the lowest fat content, at  $21.33 \pm 0.18$ . This may be due to tomatoes containing 5.8 g of lycopene per 100 grams of tomatoes. Lycopene in this study reacted more easily with fat because it was heated twice, namely during the blanching process and vacuum freezing. Other fibers such as pectin, cellulose, hemicellulose, and lignin also played a role in binding fat. (43) Mushrooms contain cholesterol-binding fibers called beta-glucan hemicellulose and pectin,

which enhance water-binding capacity and reduce density. Seaweed fiber is water-soluble because it's derived from anionic polysaccharides. Both of these substances have the ability to bind fat, but not as much or as effectively as tomato varieties.

### **Protein Content**

The protein content of vegan baby food differs significantly between tomatoes and seaweed. Meanwhile, there is no significant difference between tomato-mushroom and mushroom-seaweed. The protein content set by SNI is 8 to 22% and the standard set by BPOM is 1.9-5.5 grams/100 kcal of material. Based on this data, all baby food meet SNI and BPOM standards. The highest protein content is baby food tomato with an average of  $14.00 \pm 0.09\%$  (w/w), followed by mushrooms with an average of  $12.07 \pm 0.05\%$  (w/w), then seaweed with the lowest protein content at  $11.14 \pm 0.11\%$  (w/w). The results of these protein content calculations may be due to the processing of ingredients that involve heating to a temperature of  $50^\circ\text{C}$  in a freeze-drying machine and boiling temperatures when cooking  $>90^\circ\text{C}$  which can cause protein denaturation. (44)

In addition, differences in protein content in these ingredients are caused by variations in the addition of different amounts of ingredients and the amino acids that make up the protein itself. The addition of tomatoes is 11.7%, oyster mushrooms 7.36%, and seaweed 3.82%. Tomatoes have 1.6 grams of protein, (45) oyster mushrooms have a maximum calculated protein content of 2 grams, while seaweed protein content is 1.8 grams. The discrepancy between protein content and output is thought to be influenced by the type of amino acids in the additional ingredients. The main amino acid in tomatoes is glutamate (313 mg/100 g) with another known amino acid being tryptophan. (46)The amino acids found in oyster mushrooms are alanine, arginine, leucine, lysine, and the largest is glutamate (9.4 mg/100 grams of oyster mushrooms). (47)The amino acids found in seaweed are glutamate at 8.08 mg/100 grams of dry weight and the amino acid lysine, which is known to be most susceptible to heat processing. (48)

### **Carbohydrate Content**

The carbohydrate content in the tomato and mushroom variations of baby food did not differ significantly, namely  $58.87 \pm 0.23\%$  (w/w) and  $59.33 \pm 0.14\%$  (w/w). Meanwhile, both differed from the seaweed variation with an average of  $60.50 \pm 0.38\%$  (w/w). Based on BPOM no. 24 of 2020 and SNI 01-711.1 of 2005, there is no limit for total carbohydrate content. The high carbohydrate content in baby food is due to the use of the main ingredient, namely white sweet potato, which has 28.79 grams of carbohydrates per 100 grams and is part of an average of 61.17% of the formulation. Although there are differences in the addition of various ingredients, this does not have a significant impact because tomatoes only contribute 4.2 mg/100 grams of ingredients, (49)mushrooms have carbohydrates of 56.6% of the dry weight, (50)and seaweed as much as 6.65-15.18%. (50)

### **Total Calories**

The total calories in instant baby also need to be considered in meeting the child's nutritional needs and the portion given. Based on SNI 01-711.1 of 2005, the minimum calorie per gram of ready-to-eat product is not less than 0.8 kcal. The serving size for vegan baby food products of all variations is 1:5 for the ratio of ingredients to hot water (w:w) with an average energy of 114.66 kcal per bowl (2 rusks). From the calculation results, all baby food variations meet the standard calorie per gram with an average of 0.81 kcal/gram ready to serve. Meanwhile, BPOM Regulation No. 24 of 2020 stipulates that baby

(complementary food) contains a minimum of 240 kcal of ready-to-eat calories per day, based on serving instructions. Based on these two regulations, vegan baby food meets the established standard, which is an average of 343.98 kcal/day, assuming three meals per day.

## 5. CONCLUSION

Vegan baby food with tomato, mushroom, and seaweed variations still does not fully comply with applicable Indonesian standards, including BPOM No. 24 of 2020 and SNI 01-711.1 of 2005 for instant baby food in powder or biscuit form. Overall, the only product that met the standards and was the best formulation was the tomato variety. This recipe can be used for children with special nutritional needs (vegans) as option. Next, it is necessary to review the recipe to adjust to applicable standards.

## CONFLICT OF INTEREST

The authors declare that there were no conflicts of interest in this study.

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