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Storability of Seaweed Jelly Candy based on Chemical, Physical and Microbiology Characteristics

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Abstract. Seaweed is a valuable fishery product and becomes potential source of foreign exchange. Candy jelly, for example, is one of the results of diversified seaweed products. This study aims to determine the ability of storing seaweed jelly candy in terms of physical and micro forms. The one-shot case study method was applied in this study. Variability in shelf life was observed for four days by distinguishing the characteristics of each jelly candy (H1, H2, H3, and H4). Physical testing on this study involved 5 expert panelists. The results showed that the texture of seaweed jelly candy at safe limits was stored until the second day (II) with the characteristics of not slimy and hyphae, and the aroma produced on the second day was not rotten. In terms of color, seaweed jelly candy on day II was yellowish white and without black speckled. Microbiological test results showed the shelf life limit for seaweed jelly candy is on the second day (II) with a total plate number of 2.1×10^4 cfu/ml, while on day III (9.0×10^4) had exceeded the maximum contamination limit of 5×10^4 , which was not suitable for consumption. On the first day of storage (I) the amount of mold/yeast was 6.0×10^2 cfu / ml while on day II (2.5×10^3) which means that it has exceeded the maximum contamination limit of 103. On the fourth day of storage did not meet the criteria for consumption. The types of microorganisms growing during the storing process are *Aspergillus Niger*, *Aspergillus* sp, *Cephalosporium* sp, yeast, and *Rhizopus* sp. Seaweed jelly candy has a fat content of 0.78 grams/100 grams, iodine content of 103.36 milligrams/100 grams and pH 4.88, whereas with a water content of 14.90%, ash content of 0.52%, and reducing sugar content of 4.53%.

1. Introduction

Various food samples have been produced from local food ingredients, including seaweed. Seaweed is quite abundant, and there have been various processing and preservation efforts to increase the sale value of the seaweed. Jelly candy is one of the products of *Aloe Vera* and seaweed. This study aims to get the right ratio between *Aloe Vera* and seaweed to produce jelly candies with good quality [1]. Various treatments and preservation efforts have been carried out such as dried seaweed, jellies, *algin*, and carrageenan. These processing and preservation methods have deficiencies that the dried seaweed, jellies, *algin*, and carrageenan are categorized into raw materials that can be enjoyed after experiencing further processing. Processing of seaweed is still quite simple, such traditional foods as *dodol*, *cendol*, sweets, pudding, pickles and so on. But in accordance with the development of the human mindset, seaweed can be processed into small food product for children and adults in the form of seaweed jelly candy. Seaweed jelly candy is made from a mixture of ingredients consisting of seaweed, sugar, gelatin, salt, *pholy phospex*, essence, and coconut water. There is a wide variety of materials with film-forming ability, possessing different characteristics and subsequently affect the final product [2]. If the ingredients are mixed and cooked, it will produce a thick flowing mixture that is easy to mold.



The results of seaweed jelly candy can be enjoyed after the molding and cooling process so that the shape is clearer and more attractive, arising the appetite. Research on seaweed jelly candy has previously been carried out [3], in which states that the best products were produced based on organoleptic tests by several responses. In addition, the best products were produced through organoleptic tests with 100 grams of sugar and 150 grams of seaweed and the nutritional content of seaweed jelly candy is 23.78% carbohydrate, fat content 10.24%, protein 4.68%, ash 0.76%, water 29.81%, fiber 30.68%, and iodine 0.00%. The research has produced the ideal formula or proportion of the ingredients, the procedures of how to make it, and the criteria of yield and nutritional content. Yet research has not seen the storability of the seaweed jelly candy. In specific, this study will examine the storability of the seaweed jelly candy.

2. Materials and Method

This research employed one-shot case study to determine the percentage of observations including the color, flavor and texture of seaweed jelly candy and analyzed the microbiological test data. Data analysis stage was the key process to the problem, and after concluding the data, the next step was to analyze the data. The data obtained from this study were analyzed descriptively. Descriptive analysis referred in this study was the entire set of data and information that have been determined and collected by the researchers and explained descriptively.

2.1. Preparation Phase

This research utilized the ingredients of seaweed jelly candy listed in Table 1.

Table 1. ingredients of jelly candy

No	Ingredients	Quantity
1	Seaweed	150 g
2	Sugar	100 g
3	Gelatin Powder	20 g
4	Salt	0.5 g
5	Air kelapa	200 g
6	Coconut water	1 g

Meanwhile the equipment used to make the seaweed jelly candy are shown in Table 2.

Table 2. Jelly Candy Equipment

No	Equipment	Specs	Quantity
1	Stove	Gas Digital (0.01 g)	1
2	Scales	Jingzhun	1
3	Pan	Aluminium	1
4	Stirer	Wood	1
5	Cutting board	Plastic	1
6	Knife	Stainles steel	1
7	Food Procesor	Electric	1
8	Bowl	Plastic	1
9	Tablespoon	Stainlessteel	1
10	Candy mold	Plastic	1
11	Flour filter	Plastic	1
12	Measuring cup	Plastic	1
13	Spatula	Plastic	1

2.2. Implementation Phase

The research was conducted based on specified schedule. This activities were carried out in several stages including the creation of the seaweed jelly candy formulas including: (1) cleaning and washing of seaweed to remove any possible dirt attached to the seaweed; (2) soaking seaweed into water for one hour to obtain the desired density; (3) weighing the ingredients; (4) chopping the seaweed into smaller size around 0.5 cm; (5) smoothing the seaweed with coconut water by using a blender; (6) screening the seaweed gel to separate the dregs; (7) boiling the seaweed gel, gelatin, sugar and other ingredients over medium heat while stirring continuously for 20 minutes; (8) the gel was molded into molds that have the same shape and size to produce the expected shapes; and (9) cooling at room temperature for one day. The next stage of implementation was observation and laboratory testing (microbiological testing). Observations were carried out by five people for four consecutive days, which focused on the texture, flavor and color of seaweed jelly candy. Laboratory testing were carried out on total microbes and total mold/yeast as well as several types of microorganisms for four days at room temperature.

2.3. Data Analysis

Comprehensive data obtained by analyzing seaweed candy include:

2.3.1. Physical Analysis

In order to determine the level of acceptance of seaweed candy physically, a preference test (color, taste, flavor, texture and overall parameters) was used and a differentiation test (compactness and elasticity) involved 25 untrained panelists. The experimental design used was a completely randomized design (CRD) of factorial pattern consisting of four factors, namely the variation of storage capacity (H1, H2, H3, and H4) and the variation of observational treatments, namely physical and micro quality. The results of the research data were analyzed using ANOVA to determine whether there were differences in treatment at the level of $\alpha = 0.05$. Then proceed with DMRT at the same α level.

2.4. Microbiological Analysis

The objects were observed through microbiological tests with petri dish methods (medium PCA and PDA). PCA medium determines the maximum limit of total plate number or 10⁴, and PDA medium determines the maximum limit of mold 10³ and yeast 10³.

2.4.1. Chemical analysis

Chemical analysis was to measure fat content with the Soxhlet method, iodine content analysis conducted by difference methods, and Ph test which was used to determine acid base levels.

3. Results and discussion

The results of observations on the characteristics of physical assessment of sea weed jelly jelly in terms of texture, flavor and candy color of seaweed jelly for four days at room temperature are as follows:

3.1. Physical Analysis Results

3.1.1. Texture

On the first day (I), the panelists assessed the characteristics of non-slimy textured jelly grasses and hyphae as many as 5 panelists (100%). On the first day, the panelists did not state that the jelly was likely slimy and had hyphae, it was quite slimy and had enough hyphae, or very slimy and had hyphae. On the second day, five panelists stated that it was not slimy. The panelist also did not state a bit slimy and hyphae, quite slimy and hyphae, slimy and hyphae and very slimy and hyphae on the second day. On the third day, three panelists (60%) stated that they were not slimy and had no hyphae, while the other two panelists (40%) stated that it was rather slimy and slightly hyphae, quite slimy and quite

hyphae, slimy and as many as hyphae, while no panelists who stated it was very slimy and very hyphae (0%).

Table 3. Texture Analysis Result

Day	Percentage				
	A	B	C	D	E
I	100%	0%	0%	0%	0%
II	100%	0%	0%	0%	0%
III	60%	40%	0%	0%	0%
IV	0%	60%	40%	0%	0%

Note:

A: Not slimy and hyphae

B: Slightly slimy, slightly hyphae

C: Partly slimy, rather hyphae

D: Slimy and hyphae

E: Very slimy and very hyphae

The results describe that the texture of the seaweed jelly candy Day IV was not in a good condition and had a texture changes with criteria of slightly slimy and slightly hyphae as much as 60% and quite slimy and enough hyphae as much as 40%. Seaweed jelly candy during storage shown mucus and hyphae, and this shows the texture (physical) of candy jelly changes. This is asserted that the form of damage to processed seaweed products is moldy and slimy because of the increasing moisture content on the jelly candy so the ash content is reduced [4]. Jelly quality requirements form state (texture) is normal according to the characteristics of seaweed jelly candy which are solid with chewy texture.

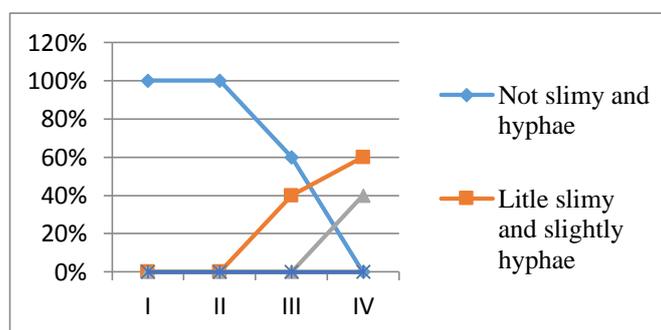


Figure 1. Percentage Diagram of Physical Analysis Result

Texture changes during storage were influenced by several factors. The seaweed jelly candy had pH of 4.88, and according to that, pH 4.6-7.0 is the optimum condition for bacterial growth. So this jelly candy was in an optimum condition for bacterial growth. This jelly candy was also categorized into a semi-wet food so it is easily overgrown by the bacteria that cause mucus. Moisture during the storing process also causes food damage [5]. The elasticity of seaweed jelly candy can be influenced by gelling ingredients such as gelatin which will give rubbery properties [5]. The optimal combination of seaweed and the right gelatin would provide elasticity of the gum that is supple and has a soft texture. Candy jelly has a high moisture content so it is an optimum condition for microbial growth. The storability of candy jelly will be reduced by the presence of food character factors and environmental conditions. The storability of the seaweed jelly candy from the texture was still proper or not dangerous is on Day III. On Day IV, there were no panelists who stated that they were not slimy and not hyphae. There were no panelists who stated slimy and hyphae as well as none of them said to be very slimy and hyphae. Various applications of these seaweed hydrocolloids as thickeners, stabilizers, coagulants and salts (in wound and burn dressings) and materials to produce bio-medical impressions in the food, pharmaceutical, and biotechnology industries are highlighted in this review [3].

4. Aroma

On the first day of storage, five panelists (100%) stated that seaweed jelly candy was not rotten; no panelists stated that the candy was rotten or failed. On the second day, all panelists stated no. The rest of the panelists did not say that they were a little rotten, quite rotten, rotten and very smells. On the third day, two panelists stated that they were not rotten, while the other panelists stated they were rather rotten. No panelist stated that it was rotten, rotten and very foul. On fourth day, no panelist stated that it was not rotten.

Table 4. Results of Aroma Analysis

Day	Percentage				
	Unrotten	Little rotten	Rotten enough	Rotten	Very Rotten
I	100%	0%	0%	0%	0%
II	100%	0%	0%	0%	0%
III	40%	60%	0%	0%	0%
IV	0%	60%	40%	0%	0%

The results indicate that the storability of the seaweed jelly candy in terms of the aroma was not appropriate on the third day. The aroma of seaweed jelly candy which previously smelled a bit of seaweed became a little foul during the storing process. This is in accordance with the statement that food damage is mainly caused by various factors, one of which is the growth of bacteria, yeast or mold on food which can damage the protein so that it results in the smells, and can also form mucus, gas, foam, acids or even poisons [1].

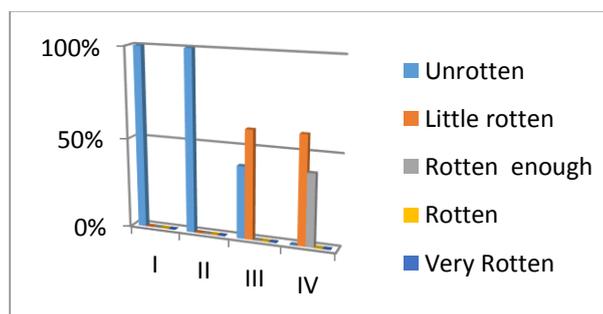


Figure 2. Results of Percentage Observation

The aroma of the jelly candy has a protein content in which becomes the optimum condition for the growth of protein-breaking bacteria so that it becomes bad smell. Besides that, spore-forming bacteria grow which form H_2 and CO_2 gases. High moisture content also causes rotting water in jelly candy. In addition [6] stated that based on the analysis of variance that seaweed jelly candy with the addition of roselle gave a significant effect on the flavor of the seaweed jelly, with $F\text{-stat} (38.5) > F\text{-table} (4.07)$ at a 95% confidence level. Based on the further test the real difference honestly the R_0 treatment was not significantly different from R_1 and R_2 , but it was markedly different from R_3 at 95% confidence level. The storing process of the jelly candy would decrease with the influence of food character factors. The storability of the seaweed jelly candy was considered feasible or not dangerous until the second day.

4.1.1. Color

On Day I, all panelists (100%) stated that seaweed jelly candy was with yellowish white characteristics had no black spots. No panelist who claimed the seaweed jelly candy was with black spots nor very yellowish white very black spots. On the second day, all panelists unanimously stated that there were no white spots nor black spots. There were no panelists who stated that jelly candy has a yellowish white color rather than black spots; yellowish white was with enough black spots, yellowish white black spots, and very yellowish with black spots. On the third day, two panelists (40%) stated that

jelly candy has a yellowish white character with no black spots, while the other three panelists stated that there were yellowish white with some black spots. There were no panelists who stated that candy jelly had quite a yellowish white character with black spots, yellowish white black spots, and very yellowish white black spots. On the fourth day, the panelists stated that there was no candy jelly with yellowish white with some black spots, whereas three panelists stated it has yellowish white with some black spots. Two panelists stated that the seaweed jelly candy had yellowish white with some black spots. Likewise, no panelists stated it had yellowish white with many black spots (Table 5).

Table 5. The storability of seaweed jelly candy in terms of the color

Day	Percentage				
	A	B	C	D	E
I	100%	0%	0%	0%	0%
II	100%	0%	0%	0%	0%
III	40%	60%	0%	0%	0%
IV	0%	60%	40%	0%	0%

Note:

A: Yellowish white, no black spots

B: Yellowish white rather black spots

C: Yellowish white with some black spots

D: Yellowish white with black spots

E: Very yellowish white many black spots

These results indicate the storability of seaweed jelly candy in terms of the color is not appropriate on the third day in which was yellowish white with no black spots (40%) and yellowish white with rather black spots (60%). The color of the jelly candy changed during the storing process which is considered as normal (in terms of color) according to the characteristics of transparent and yellowish white color. This is in accordance with the study [7] that the form of damage to the processed seaweed products can be characterized by changes in color. The optimum conditions for microbial growth are moisture, pH, and supporting water content. One type of mold is *Aspergillus Niger* (black).

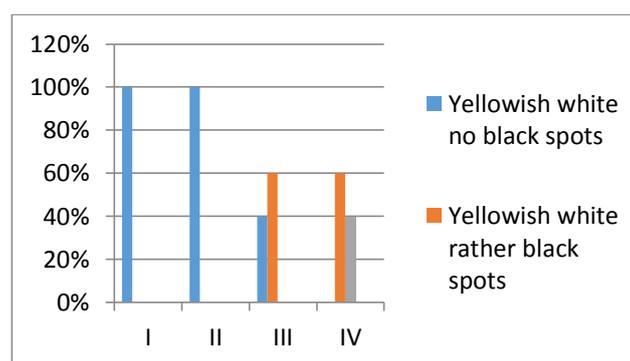


Figure 3. Percentage Diagram of Observation Results

These results indicate that storability of the jelly candy will decrease with the presence of food character factors and environmental conditions. In terms of the color, the seaweed jelly candy is still appropriate and edible until the second day, while on the thir day is no longer edible due to the presence of microbial growth and mold/yeast. It means that the seaweed jelly candy is considered still edible and harmless on second day with the following criteria, namely 1) no slimy texture and no hyphae, 2) no foul flavor, and 3) no yellowish white spots.

4.2. Results of Chemical Analysis

Table 6. Results of Chemical Analysis

Parameters	Level
Fat (g/100 g)	0.78
iodium (mg/ 100 g)	103.36
pH	4.88

It can be seen that the nutritional content of seaweed jelly candy is that every 100 grams there are 0.78 grams of fat content, 103.36 milligrams of iodine content, and pH (acidity level) of 4.88. Fat content in the formula [8] is large compared to the fat content tested in this study. In the formula [8], there are no ingredients that contain high fat content. So that the seaweed jelly candy does not have high fat content. There is also significant difference in terms of iodine content. Previous studies [9] did not have iodine content, whereas according to the recent study [10] indicates that the seaweed is an iodine-containing food. If there is a processing, not too much iodine would have lost. In accordance with subsequent chemical tests, the iodine content is 103.36 milligrams / gram. In terms of the pH, this seaweed jelly candy is likely categorized into durable food with a mid pH (4.5-5.3) as it has a pH of 4.88. The acid content of this candy is gained from gelatin and without the addition of other acids, so this jelly candy has a middle level of acidity (pH).

Water content of seaweed jelly candy water ranged from 13.7-15.1%, and it is still in accordance with the water content requirements in Indonesian National Standard (SNI) of 3547.2-2008 for candy jelly, with a maximum value of 20%. Levels of seaweed jelly candy ash ranged from 0.38 to 0.44%. The concentration of the four treatments was the same, 10%, so there was no significant difference in ash levels between the four treatments. The ash content in jelly candy is still in accordance with jelly candy quality standards (SNI 3574.2-2008) with a maximum value of 3.0%. The sucrose levels of seaweed jelly candy ranged from 30.62 to 67.54%. The levels of sucrose from all treatments exceeded the set value so that they did not meet jelly candy quality standards (SNI 3574.2-2008) which is minimum of 27%.

4.3. Results of Microbiological Analysis

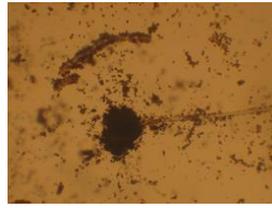
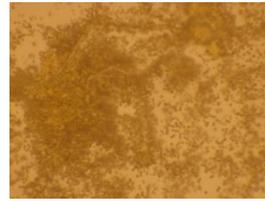
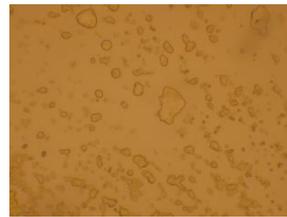
The results of the microbiological test of seaweed jelly candy after being tested in a laboratory for five consecutive days are presented in the following Table 7.

Table 7. Results of Microbiological Analysis

Micro Check	Storages/Day				
	0	I	II	III	IV
Total microbes (cfu/ml)	2.1×10^2	4.2×10^3	2.1×10^4	9.0×10^4	1.6×10^5
Total yeast (cfu/ml)	8.9×10^1	6.0×10^2	2.5×10^3	6.0×10^4	1.2×10^5

On day 0, seaweed jelly candy showed there were total microbes (total plate count) of 2.1×10^2 cfu/ml and total mold/yeast of 8.9×10^1 cfu/ml. On Day I, seaweed jelly candy showed there were total microbes of 4.2×10^3 cfu/ml and total mold/yeast of 6.0×10^2 cfu / ml. On Day II, seaweed jelly candy showed there were total microbes of 2.1×10^4 cfu/ml and total mold/yeast of 2.5×10^3 cfu/ml. On the Day III, seaweed jelly candy showed there were total microbes of 9.0×10^4 cfu/ml and total mold/yeast of 6.0×10^4 cfu/ml. On Day IV, seaweed jelly candy showed there were total microbes of 1.6×10^5 cfu/ml and total mold/yeast 1.2×10^5 cfu/ml. Protein is the highest content in gelatin as gelatin is as one type of conversion proteins produced through the process of collagen hydrolysis which basically has a high protein content [11].

Some microorganisms that grown on the seaweed jelly candy during observation (microbiological test) are *Aspergillus Niger*, *Aspergillus* sp., *Cephalosporium* sp, yeast, and *Rhizopus* sp.

**Figure 4** *Aspergillus Niger***Figure 5** *Aspergillus Sp.***Figure 6.** *Cephalosporium Sp***Figure 7.** Yeast**Figure 8** *Rhizopus Sp*

These results indicate that the quality of seaweed candy jelly has decreased as the number of microorganisms mold/yeast and bacteria increased. This might be the reason why the seaweed candy jelly lasted only a few days [12]. According to SNI, candy jelly can be categorized to be safe for consumption with the maximum limit of 5×10^4 for the total plate number (bacteria) and 103 for mold/yeast. Based on the observation, the seaweed jelly candy is safely consumed on Day II by seeing the plate number (2.1×10^4) because the number has exceeded on the next day. In addition, the seaweed jelly candy is also said to be safe with total mold/yeast on Day I (6.0×10^2) as it was in accordance with SNI, namely the maximum total mold / yeast of 103.

Data analysis shows total microbial growth was faster in the beginning phase than growth of mold/yeast; whereas on Day III, the growth of mold/yeast was faster than microbial growth (especially proteolytic bacteria / bacteria cannot stand with acid). Ref. [13] mentioned that seaweed jelly candy has a pH of 4.88, and the pH tends to decrease, this was thought due to the growing acidic bacteria, so the pH will decrease or become acidic. These conditions benefit mold/yeast and bacteria (especially acid-resistant bacteria) which are increasingly depressed. Growth of yeast fungi is also supported by optimum growth temperatures at room temperature [14]. This is consistent with the statement that the growth temperature range of most molds and yeast in general is the optimum 25-30°C. For that on Day III, the growth of mold/yeast was more dominant. Some microorganisms that grew on seaweed jelly candy during observation (microbiological test) are in *Aspergillus* sp with the following characteristics, namely (1) septate hyphae and branched mycelium, usually colorless, which are located below the surface are classified into vegetative hyphae, whereas those appearing above the surface generally are a fertile

hyphae and have a compact colony; (2) septate or non-septate conidiophores, arising from the foot cell (ie, swollen and thick-walled mycelium cells) and swell into vesicles at the ends, carrying the sterigmata where conidia grows; (3) Sterigmata or fialides are usually simple, either colored or colorless; (4) Conidia forms chains that are green, brown or black. Some species grow well at 37°C or more. In addition, *Aspergillus Niger* has the following characteristics, namely (1) having a large conidial carrying head that is packed tightly, round and black, brown-black or purple-brown; (2) the conidia is rough and contains pigments; (3) most strains in this group have gray to black sclerotia; (4) some strains are used in the production of citric acid, gluconic acid and enzymes. The last is *Cephalosporium* sp whose specific characteristics of septic mycelium, conidia is colorless, either elliptical or elliptical, appearing at the ends of the conidiophores which secrete mucus fluid because of the presence of this fluid conidia united to form a sphere [15]. Yeast is a fungus, but it is different from mold because of its mainly unicellular form. Vegetative reproduction occurs by budding. Yeast has a larger surface area ratio than mold. Yeast is bigger in size and its morphology is different from bacteria [16]. Many bacteria are actually not harmful to health, but if they grow and multiply in food until they reach very high amounts, it may cause food damage, which causes smells, mucus, acid, discoloration, gas formation, and other changes that are desired expected by the body. Bacteria that cause symptoms of illness or poisonous are called pathogenic bacteria or pathogens. This kind of pathogens, for example, are classified as coli (*Escherichia Coli*), *Salmonella* and *Shigella*. Bacteria belonging to the poisoning bacteria such as *Staphylococcus aureus*, *Clostridium perfringens*, and *Bacillus* sp which produce toxins that attack the digestive tract and are called enterotoxins, and *Clostridium botulinum* which produces nerve-attacking toxins and can cause paralysis of the throat tract and called neurotoxins or botulinum toxins [17]. Some molds as they are growing on food can produce harmful toxins or mycotoxins. Mold species that produce mycotoxins are mainly *Aspergillus*, *Penicillium* and *Fusarium* types. Seaweed products can be overgrown with pathogenic bacteria (causing poisoning, paralysis), so that products contaminated with microbes (such as *Bacillus* sp bacteria) which are more dangerous than products contaminated with mold/yeast.

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