Effect of the Addition of Carboxymethyl Cellulose and Lemon Extract on the Physical, Chemical Properties, and Preference Level of White Turmeric (*Curcuma mangga* Val.) Juice

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Abstract. Health drinks are one of the products widely known to the public and commonly found on the market in various brands and forms, such as liquid, instant powder, or tablets. One potential ingredient to be developed into a health drink is white turmeric (*Curcuma mangga* Val.). The addition of lemon juice can increase vitamin C and citric acid content, which provides a refreshing effect, enhances the characteristic sour flavor, maintains color stability, and helps extend the product's shelf life. The importance of this research is to create a functional beverage containing vitamin C that can be consumed by all communities. This study aims to determine the effect of the addition of CMC and lemon extract on the physical, chemical properties and preference level of white turmeric juice. The research was carried out with the preparation of the rhizome, including sorting, peeling, washing, grating, and pressing. The white turmeric extract was then mixed with CMC and lemon extract and cooked for 5 minutes. The study used a Completely Randomized Design (CRD) with 2 replications. The first factor was carboxymethyl cellulose of 0.75, 1.00, and 1.25 g, and the second factor was lemon extract with concentrations of 2.5, 5.0, and 7.5 ml of the 1000 ml white turmeric juice. The analysis including physical properties, and chemical properties (including antioxidant activity, total phenol content, and pH) and preference level. The data were statistically analyzed using ANOVA (Analysis of Variance), and if significant differences were found, further analysis was conducted using DMRT (Duncan Multiple Range Test) with SPSS 25.0. The best formulation was obtained from the addition of 7.5 ml lemon extract and 0.75 g CMC, which produced the highest panelist acceptance with a score of 3.72 as selected sample for further chemical analysis. The white turmeric drink from this formulation had an antioxidant activity of 17.52% RSA, a pH of 3.37, and a total phenol content of 0.35 mg GAE/g.

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1 Introduction

Indonesia is a country that has very high biodiversity, including various types of herbal plants. Herbal plants have long been used by the community because they have various health benefits. One of the groups of herbal plants that are widely used rhizome, which has been processed into various functional food products, such as health drinks. Health drinks are drinks that contain both nutritional and non-nutritional elements and if consumed can have a positive effect on the health of the body. Health drinks are one of the products that are known to the public and are widely found on the market with various brands and forms, such as in liquid, instant powder or tablet form. Health drinks are one of the products that are known to the public and are widely found on the market with various brands and forms, such as in liquid, instant powder or tablet form One of the potential ingredients to be developed into a white turmeric (*Curcuma mangga* Val.) juice. White turmeric is one of the ingredients that has great potential as a natural source of antioxidants [1]. White turmeric has great potential to be developed, because white turmeric contains curcuminoid compounds and polyphenol compounds that cause these ingredients to have high antioxidant activity. Several studies report that *Curcuma mangga* rhizomes have anti-cancer [2] and antioxidant properties[3]. In addition, white turmeric also contains rutin compounds and quercetin which show strong antioxidant activity. Another study on white turmeric functional beverages with 5% lemon added showed a total phenol content of 113.44 mg GAE/L and antioxidant activity of 50.817 mg GAE/L [4].

The use of stabilizing ingredients plays an important role in maintaining product stability in the manufacture of juice drinks. One of the ingredients that is often used is Carboxymethyl Cellulose (CMC), which functions to improve the stability of the emulsion and prevent sugar crystallization. The advantages of CMC are odorless and tasteless, therefore this stabilizer was chosen in the manufacture of juice drink.

Lemon (*Citrus limon*) also has great potential to be combined in the manufacture of health drinks. Lemons contain vitamin C, citric acid, as well as flavonoid compounds such as hesperidin and eriocitrin which act as natural antioxidants [5]. The content of vitamin C and citric acid in lemons not only provides a refreshing effect and adds a distinctive sour taste, but can also improve color stability and help extend the shelf life of the product. The combination of white turmeric extract and lemon is expected to be able to produce a health drink with high antioxidant activity and a taste that is more accepted by consumers.

This study was conducted with blanching as a preliminary treatment to improve the physical and chemical properties of white turmeric juice with the addition of lemon, as previous studies did not involve blanching. Therefore, this study aims to determine the effect of the comparison of white turmeric extract and lemon extract with the addition of CMC as a stabilizer, so that it produces a white turmeric juice that is stable, has high antioxidant activity, and is acceptable to consumers.

2 Materials And Methods

2.1 Materials

The ingredients used in this study include white turmeric (*Curcuma mangga* Val.) obtained from CV Windra Mekar, Carboxymethyl Cellulose (CMC) obtained from Progo Mulyo, and fresh lemon and granulated sugar obtained from Demangan Market, Yogyakarta. The chemicals used for analysis included 96% ethanol (Merck, Germany), DPPH (1,1-diphenyl-2-pykrilhydrazil) 0.1 mM (Sigma-Aldrich, USA), BHT (Butylated Hydroxytoluene) (Sigma-

Aldrich, USA), aqueducts (UMBY Food Chemistry Laboratory production), Follin ciocalteu (merck), and Na_2CO_3 20% (Merck).

2.2 Equipment

The tools used in the study included stainless steel basins (Lion Star, Indonesia), stainless steel graters and knives (Maspion, Indonesia), boiling pots (Kirin, Indonesia), filter cloths (musculin), wooden spatulas, non-stick pans, and 60 mesh stainless steel sieve (Retsch, Germany). The analysis equipment used includes measuring cups, beakers, measuring pipettes, drip pipettes, and measuring flasks (Pyrex, USA), Ohaus Pioneer PA214 analytical scales (USA), Shimadzu UV-1800 UV-Vis spectrophotometer (Japan), vortex mixers (Thermo Fisher Scientific, USA), test tubes (Iwaki, Japan), Kjeldahl flasks (Gerhardt, Germany), burettes and statifs (Pyrex, USA), and porcelain cups (Iwaki, Japan).

2.3 Research Methods

2.3.1 Turmeric Juice preparation

The process of making white turmeric juice is carried out through several stages. The first stage is sorting, which is the selection of white turmeric rhizomes that are still fresh and no deterioration. Next, stripping is carried out to remove the outer skin of the rhizome, then washing using clean water to be free from dirt and soil. After that, 100 g of clean white turmeric rhizomes are grated, then filtered to obtain white turmeric juice.

The juice obtained is then cooked with the addition of Carboxymethyl Cellulose (CMC) at various concentrations, namely 0.75; 1.00; and 1.25 g, as well as lemon extract with concentration variations of 2.5; 5.0; and 7.5 ml to the 1000 ml white turmeric juice. The addition of water is done up to a certain volume according to the formulation. The cooking process is carried out until the ingredients are homogeneous and form an white turmeric juice drink. The resulting beverage products were then tested including a preference level test (hedonic test) to determine the acceptance of the panelists, a physical property test in the form of viscosity measurement, and a chemical test that included antioxidant activity (DPPH method), total phenol content, and product pH.

3 Analysis

3.1 Preference Level

The preference level test was carried out using the scoring hedonic test method to determine the level of acceptance of panelists for white turmeric drink products. The attributes assessed include color, aroma, taste, and overall. The assessment was carried out by semi-trained panelists using an assessment scale of 1-5 where 1 strongly disliked, 5 strongly liked.

3.2 Chemical Analysis

3.2.1 Antioxidant activity

Analysis of antioxidant activity was carried out using the DPPH method [6]. Samples of 0.2 ml plus 3.8 ml of 0.1 mM DPPH solution, were disvorced for 1 minute using a vortex mixer (Maxi Mix II type 37600, UK), and incubated at room temperature of 27 °C and dark room

for 30 minutes. Absorbance was indicated at λ 517 nm with a UV-Vis spectrophotometer (Genesys, USA). Blank (control) using pure ethanol. Free radical scavenging power is expressed in percent (%) RSA = % Radical Scavenging Activity which is % of DPPH discharge. The DPPH solution is made by weighing 2.2-diphenyl-1-picrylhydrazyl powder as much as 0.0039 g and dissolved in 100 ml of ethanol so that a DPPH concentration of 0.1 mM is obtained. The formula for calculating the antioxidant activity of DPPH is as follows.

$$\%\text{RSA} = \frac{\text{Abs control-Abs sample}}{\text{Abs control}} \times 100\% \quad (1)$$

3.2.2 Moisture content [7]

The weighing bottle and lid are dried in the oven for 5 hours, then cooled in a desiccant for 10 minutes, then weighed (= W0 g). Weigh approximately 1-2 g of the sample in such a weighing bottle, the sample is evenly distributed (= W1 g). Place the weighing bottle with its contents and lid in the oven for 5 hours. Avoid contact between the weighing bottle and the oven wall. Remove the weighing bottle along with the contents and cool it in a desiccant then weigh it (= W2 g). Dry again in the oven and weigh until a fixed weight is obtained (at least once every 3 hours). The analysis was carried out in 2 *batches* of 2 repeats each.
Account:

$$\text{Moisture content (\% wet basis)} = \frac{W1-W2}{W1-W0} \times 100\% \quad (2)$$

3.2.3 Total phenol content with follin-ciocalteu method [8]

Sample as much as 50 µl, 250 µl of folin-ciocalteu solution was added, then let it sit for 1 minute and added 750 µl of Na_2CO_3 20%, then divortex for 1 minute using a vortex mixer (Maxi Mix II type 37600, UK), and added aqueduct to a volume of 5 ml. After that it was left for 2 hours at room temperature of 27 °C without light, absorbance was marked at λ 760 nm with a UV-Vis spectrophotometer (Genesys, USA). The formula for calculating total phenolics is as follows.
Total phenol content (mg GAE/g wb)=

$$\frac{\text{Consentration of ppm} \times 100}{\text{Sample weight}}$$

Total phenol content (mg GAE/g db)=

$$\frac{\text{Kadar fenol (bb)}}{\text{dry weight of sample}}$$

3.2.4 Experimental Design

The experimental design used in this study was a factorial Complete Random Design (RAL) with 2 factors. The factors used were the percentage of addition of CMC variation 0.75; 1.00 and 1.25%. And the lemon juice variation is 25, 50 and 75%. Treat 9 units of experiments and do two repetitio.

3.2.5 Data Analysis

The data from the research were statistically analyzed using ANOVA (Analysis of Variance) and if there were significant differences, they would be further processed with the DMRT (Duncan Multiple Range Test) test or the Duncan double distance test with the help of SPSS (Statistical product and service solution) software version 25.0.

4 Results And Discussion

4.1 Chemical Properties

4.1.1 pH value

The pH value of white turmeric health drink is presented in Table 1.

Table 1. pH level of White Turmeric (*Curcuma mangga* Val.) Juice Stabilized by CMC

Lemon Extract (ml)	CMC (g)		
	0.75	**1.00**	**1.25**
2.5	3.81±0.11[a]	3.80±0.18[b]	3.80±0.20[b]
5.0	3.71±0.62[c]	3.67±0.01[c]	3.74±0.05[c]
7.5	3.37±0.13[b]	3.40±0.16[b]	3.55±0.01[bc]

Notes: Numbers followed by different letters in the same column show a noticeable difference at a 95% confidence level ($\alpha<0.05$).

Table 1 shows that the addition of lemon extract has a significant effect on the pH value of white turmeric juice drinks. The pH value tends to decrease as the volume of lemon extract is increased. This decrease in pH is caused by the natural acidic properties of lemons that contain citric acid and ascorbic acid (vitamin C). Both organic acids release H^+ ions when dissolved in water, thus being able to significantly lower the pH of the solution. Lemon juice has a pH of about 2-3 and a citric acid content of 5-8% [9], so that the larger the volume of lemon extract added to the beverage formulation, the higher the concentration of H^+ ions in the solution. This condition causes the drink to become more acidic as the addition of lemon extract increases. This is also supported by research that reports that an increased proportion of lemons in juice lowers pH [10].

A decrease in pH values is also related to the stability of bioactive compounds in the beverage. Acidic conditions can help maintain the stability of the pigments and phenolic compounds of white turmeric, especially curcuminoids, which tend to be more stable at low pH. Phenolic compounds and ascorbic acid work more optimally in more acidic pH conditions. Antioxidant activity is related to the ability of compounds to donate hydrogen atoms or electrons in inhibiting the formation of free radicals. The combination of lemon extract and white turmeric juice not only causes a decrease in pH, but also has the potential to increase the antioxidant activity of the product due to the synergy between phenolic compounds and vitamin C from lemons with curcuminoids from white turmeric. The addition of lemon extract not only affects the chemical properties of the drink through a decrease in pH, but also contributes to the increased stability and functional potential of the white turmeric drink as a natural source of antioxidants.

4.1.2 Antioxidant activity (%RSA)

The antioxidant content of white turmeric juice drink is presented in Table 2 as follows.

Table 2. Antioxidant Activity (%RSA) of White Turmeric (*Curcuma mangga* Val.) Juice Stabilized by CMC

Lemon Extract (ml)	CMC (g)		
	0.75	**1.00**	**1.25**
2.5	14.04±0.04[a]	14.44±0.01[b]	15.40±0.13[c]
5.0	17.06±0.06[d]	17.18±0.23[d]	17.92±0.05[f]
7.5	17.52±0.40[e]	17.77±0.2[ef]	17.93 ±0.05[f]

Notes: Numbers followed by different letters in the same column show a noticeable difference at a 95% confidence level (α<0.05).

Table 2 shows that white turmeric health drinks with variations of lemon extract and CMC added had significantly different antioxidant activity, with values ranging from 14.04% to 17.93% RSA. The lowest value of antioxidant activity was obtained in the treatment with the addition of CMC 0.75 g and lemon extract 2.5 ml, while the highest value was obtained in the treatment with the addition of CMC 1.25 g and lemon extract 7.5 ml. This shows that the higher the concentration of CMC and lemon extract added, the more the antioxidant activity of white turmeric juice drink.

The increase in antioxidant activity along with the addition of lemon extract is related to the content of bioactive compounds in lemons, such as ascorbic acid (vitamin C) and flavonoids, which acts as an electron donor to neutralize DPPH free radicals. These results are also in line with the pH data (Table 1), where the higher the addition of lemons leads to a decrease in the pH of the drink. More acidic conditions can help maintain the stability of phenolic compounds and curcuminoids in white turmeric, thus increasing its antioxidant abilities. The antioxidant activity of a compound is greatly influenced by its ability to donate protons or electrons to neutralize free radicals.

The role of CMC as a stabilizing agent also has a positive influence on the stability of the active compound. CMC has hydrophilic properties and is able to form a stable dispersion system in the solution, thus preventing the deposition and degradation of bioactive compounds during storage. According to [11], the higher the concentration of CMC, the more stable the dispersion system formed, so that active compounds such as curcuminoids and ascorbic acid are better protected from oxidation and degradation processes.

Although the %RSA value in white turmeric juice drink products was lower, the synergistic effect was demonstrated by the combination of white turmeric extract, lemon, and CMC which showed a positive synergistic effect on the improvement of the stability and effectiveness of antioxidant compounds. The addition of lemon extract and CMC not only improves the physical characteristics of the drink, but is also able to improve the overall antioxidant ability of the product.

4.1.3 Total Fenol Content (mg GAE/g)

The total phenol content of white turmeric juice drink is presented in Table 3 as follows.

Table 3. Phenol content White Turmeric (*Curcuma mangga* Val.) Juice Stabilized by CMC

Lemon Extract (ml)	**CMC (g)**		
	0.75	**1.00**	**1.25**
2.5	0.13±0.01^{b}	0.14 ±0.01^{b}	0.24±0.02^{c}
5.0	0.14±0.00^{b}	0.10±0.01^{a}	0.15±0.00^{b}
7.5	0.25±0.02^{c}	0.24±0.02^{c}	0.25±0.02 ^{c}

Notes: Numbers followed by different letters in the same column show a noticeable difference at a 95% confidence level (α<0.05).

Table 5 shows the total phenol levels of the drink ranging from 0.10 to 0.25 mg GAE/g. The lowest phenol levels were found in the treatment with the addition of 1.00 g CMC and 5.0 ml of lemon extract, while the highest values were obtained in the treatment with the addition of 7.5 ml of lemon extract to all CMC variations. These results show that the more lemon extract is added, the total phenol content of the white turmeric juice drink tends to increase significantly.

The increase in total phenol levels along with the addition of lemon extract is thought to be related to the content of bioactive compounds in lemons, especially phenolic groups such as phenolic acids and flavonoids. These compounds play an important role in antioxidant activity because they are able to donate hydrogen atoms to neutralize free radicals.

The relationship between total phenol levels and antioxidant activity was also consistent in the results of this study. Treatments with high levels of phenols showed greater value of antioxidant activity. This is in accordance with previous research by [12] which states that the phenolic compounds in white turmeric, such as curcuminoids and polyphenols, contribute greatly to its antioxidant abilities. The addition of lemon extract further enriches the total phenolic content in the beverage system, so that its antioxidant activity increases.

CMC as a stabilizer also helps maintain the stability of phenolic compounds in the solution. The hydrophilic structure of CMC is able to protect the active compound from oxidative degradation by forming a protective layer in the dispersion system. The combination of white turmeric extract, lemon, and CMC not only improves the physical characteristics of the drink but also improves the content and stability of bioactive compounds that play a role in antioxidant activity.

4.2 Physical Properties

4.2.1 Viscosity Value

The viscosity value of white turmeric juice drink is presented in Table 4.

Table 4. Viscosity White Turmeric (*Curcuma mangga* Val.) Juice stabilized by CMC (cP)

Lemon Extract (ml)	CMC (g)		
	0.75	**1.00**	**1.25**
2.5	8.78 ± 0.12^{e}	8.80 ± 0.04^{d}	8.84 ± 0.16^{e}
5.0	6.70 ± 0.12^{b}	7.74 ± 0.03^{c}	8.27 ± 0.12^{a}
7.5	9.68 ± 0.01^{h}	9.26 ± 0.02^{g}	9.08 ± 0.04^{f}

Notes: Numbers followed by different letters in the same column show a noticeable difference at a 95% confidence level ($\alpha<0.05$).

Table 4 shows the viscosity value of white turmeric juice drink with variations in the addition of lemon extract and CMC shows a noticeable difference, with a value range between 6.70 to 9.68 cP. The highest viscosity was obtained in the treatment with the addition of 7.5 ml of lemon extract and 0.75 g of CMC, while the lowest value was found in the treatment of 5.0 ml of lemon extract and 0.75 g of CMC.

This increased viscosity is related to the role of CMC as a stabilizing and thickening agent. CMC is able to bind water and increase the viscosity of the liquid phase, thus stabilizing other components in the system and preventing syneresis from occurring. The interaction between the phenolic compounds of lemon extract and CMC molecules can also contribute to increased viscosity, due to the formation of molecular networks that strengthen the dispersion structure in the beverage.

4.2.2 Preference levels

The test of the level of preference carried out on the white turmeric juice drink with the addition of CMC and lemon aimed to determine the level of preference of the panelists for the white turmeric juice drink products produced. The assessment was carried out by giving

a score from 1 to 5 (1= very dislike, 2= dislike, 3= somewhat liked, 4= like, 5= very like). The level of preference test used the hedonic method with 25 panelists.

The quality parameters used to test the preference of white turmeric juice drinks in this study include aroma, color, taste and overall. The value of the level of preference for white turmeric juice is presented in Table 5.

Table 5. Preference Levels White Turmeric (*Curcuma mangga* Val.) Juice Stabilized by CMC

Addition Variations		Parameter			
Lemon extract (ml)	**CMC (g)**	**Color**	**Aroma**	**Flavor**	**Overall**
2.5	0.75	3.04^{abc}	2.64^{a}	2.68^{ab}	3.76^{a}
	1	3.48^{cde}	2.96^{ab}	3.12^{abc}	3.24^{abc}
	1.25	3.16^{abcd}	3.08^{ab}	3.08^{abc}	3.16^{abc}
5.0	0.75	3.76a	2.84^{ab}	2.96^{abc}	2.88^{ab}
	1	2.60^{a}	2.68^{a}	2.60^{a}	2.72^{a}
	1.25	2.92^{ab}	2.84^{ab}	2.84^{ab}	3.00^{ab}
7.5	0.75	3.92^{f}	3.40^{b}	3.56^{ab}	3.72^{c}
	1	3.44^{bcde}	3.40^{a}	3.28^{bc}	3.36^{bc}
	1.25	3.64^{de}	3.20^{ab}	3.24^{abc}	3.20^{abc}

Notes: Numbers followed by different letters in the same column show a noticeable difference at a 95% confidence level ($\alpha<0.05$).

Variance analysis calculations show that the addition of lemon extract and CMC exerts a noticeable influence on color, aroma, taste and overall. The following is an elaboration of the analysis of the results of the test of the level of preference of white turmeric juice drinks that have been carried out.

4.2.3 Color

Color is one of the first sensory parameters observed by consumers and is an indicator of product quality. Attractive colors can increase the appeal of a product, while distorted colors often lower consumer acceptance. The color also reflects the freshness and ripeness of the food.

Table 5 shows the value of liking for colors ranging from 2.60 to 3.92. Panelists were the least color preferences in the treatment with 5.0 ml of lemon extract and 1.0 g of CMC (2.60), while the most preferred color was found in the treatment of 7.5 ml of lemon extract and 0.75 g of CMC (3.92).

This difference in color preference is thought to be caused by variations in the concentration of lemon extract that affect the intensity of the natural yellow color of white turmer. The use of organic acids can affect the color intensity and stability of pigments (including curcumin/color components in turmeric) so that the combination of lemon-turmeric extract has the potential to change consumers' color perception [13]. The addition of high amounts of lemon extract can improve color clarity, as the acidic pH of lemons helps stabilize the curcuminoid pigment. Meanwhile, a concentration of CMC that is too high can make the display more cloudy. Therefore, the combination of 7.5 ml of lemon and 0.75 g of CMC produced the most attractive and preferred color of the panelists.

4.2.4 Aroma

Aroma is one of the important factors that determine consumer acceptance of food products. A distinctive aroma that does not deviate from the character of the original material will be preferred. The test results showed that the preference value for aroma ranged from 2.64–3.40, with the lowest aroma in the treatment of 2.5 ml of lemon extract and 0.75 g of CMC (2.64), and the highest aroma in the treatment of 7.5 ml of lemon extract and 0.75 g of CMC and 7.5 ml of lemon and 1.0 g of CMC (3.40).

The strong distinctive aroma of white turmeric can be partially masked by the fresh aroma of lemon, resulting in a preferable balance of aromas. The addition of a higher amount of lemon plays a role in giving the impression of a fresh citrus aroma [14] and reduces the typical smell of white turmeric, while CMC plays a role in maintaining the stability of volatile compounds in beverages. This is supported by microencapsulation research showing that CMC can form a layer around volatile compounds and decrease their release rate, thus retaining the aroma in the solution [15].

4.2.5 Taste

Taste is the main factor that determines whether a food product is accepted or not. Taste is the final determinant for consumers in assessing the quality and quality of products. Table 5 shows the value of taste preferences ranging from 2.60 to 3.56. Panelists liked the taste the least on the 5.0 ml lemon and 1.0 g CMC (2.60) treatments, while the most liked were 7.5 ml of lemon and 0.75 g CMC (3.56).

An increase in lemon concentration to 7.5 ml provides a balance of flavor between the fresh acidity of lemon and the distinctive flavor of white turmeric that is slightly bitter. However, the use of CMC that is too high can change the texture of the liquid so that it gives an uncomfortable mouth sensation. The proportional combination of lemon and CMC resulted in a more harmonious and accepted taste by the panelists.

4.2.6 Overall

The overall assessment includes all the sensory parameters of color, aroma, and taste that together determine the level of consumer acceptance. The overall average liking score ranged from 2.72 to 3.72, which falls into the category of "somewhat dislike" to "somewhat like". The most preferred treatment overall is the addition of 7.5 ml of lemon extract and 0.75 g of CMC (3.72). This combination is considered to provide bright colors, fresh aromas, and balanced flavors. These results show that the formulation is the best composition in producing white turmeric juice drinks with the most sensory quality that the panelists can accept.

5 Conclusion

The addition of lemon extract and CMC has a real influence on the physical, chemical, and preferences properties of white turmeric juice. The best formulation was obtained by the addition of 7.5 ml of lemon extract and 0.75 g of CMC, which resulted in the highest level of preference among the panelists with a score of 3.72. The white turmeric juice drink in the formulation has antioxidant activity of 17.52% RSA, pH of 3.37, and total phenol content of 0.35 mg GAE/g. These results show that the addition of lemon extract is able to increase the content of bioactive compounds and antioxidant activity, while the addition of CMC plays a role in improving the stability and viscosity of the drink. This research needs to be developed in terms of the application of preservatives or suitable types of packaging and shelf life so that the product does not spoil easily.

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