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Quality evaluation of polypropylene packaged corn yogurt during storage

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Abstract. Packaging is an important factor to control the process of quality decrease of any food product, including to determine the shelf life. The objective of this study was to determine changes quality of corn yogurt packaged using polypropylene. The method were using was package yogurt polypropylene, then it was stored in a refrigerator at 5, 10, or 15^{o}C during 21 days. The yogurt was analysed every 7 days over a 21-day period. The results indicate that protein content decreased during storage, while the lactic acid bacteria, total acid, pH, viscosity, and total solids were increased. At the end of storage, the amount of lactic acid bacteria still fulfil the minimum requirements of a probiotic food, with a count of 6.407 log CFU/g. Overal scoring by panelist (scores ranged from 0 to 5) have a 4.78 at the beginning of storage. By the 21st day of storage, yogurt was packaging using transparent polypropylene having a score of 3.85, and that stored in opaque white packaging having a value of 3.95.

1. Introduction

Yoghurt is one of dairy-based probiotic products which is much sold on the market. People who are allergic to milk protein require an alternative ingredient of yoghurt. For example, Yoghurt with vegetable as the raw material such as peanuts and soybeans [1], [2]. [3] developed probiotic corn extract which has similar characteristic to yogurt in which it has 8.74 log CFU/g of total lactic acid bacteria (BAL). This shows that sweet corn extract is qualified as a probiotic food which requires lactic acid bacteria of 6 log CFU/g [4].

Changes during the storage will affect the food quality. The stability of food products is related to the speed of physical damage due to the changes of chemical substance, physic and microbiology. Temperature is a factor which affects the changes in food product quality. When food is stored, the storage room temperature is constant. For fermentation products' storage, the temperature is very much affect the storage time. For fermentation products whose bacteria is alive, its storage time is short and it should be stored at 4° C. According to [5], the storage of yogurt at 4°C will decrease the viability of lactic acid bacteria.

Pasteurized or sterilized fermentation products have a longer storage time, but its condition also depends on the type of packaging [6]. The packaging commonly used for yoghurt is a polypropylene cup due to its small surface area so it can reduce the contact of the ingredients with oxygen. Generally, the polypropylene packaging used is transparent and opaque. The opaque polypropylene packaging is not transparent so it can provide different qualities during the storage.

The aim of this research is to know the quality change of corn yoghurt which is packed with transparent and opaque polypropylene at 5, 10 and 15°C.

2. Experimental details

2.1. The making of corn yogurt

The method used to produce corn yogurt was that reported by [3]. A corn extract was prepared and combined with 15% sweet potato, 10% mung bean extract, 15% sugar, and 10% skimmed milk powder. The mixture was pasteurized at 70°C for 15 minutes, then cooled to 40–43°C. A mixed culture of *Lactobacillus bulgaricus* and *Streptococcus thermophilus* were then added. The final mixture was incubated for 8 hours at 37°C.

2.2. Package and storage of corn yogurt

Corn yogurt was then packed with transparent and white cups. Storage was done on refrigerator at 5°C, 10°C and 15°C for 21 days. The data were analyzed every 7 days for 21 days.

2.3. Analysis of samples

The research variables observed was total lactic acid bacteria using plate count method and M.R.S Agar media [7]; the pH measurement was carried out by potentiometric method, by using pH meters in all experimental units, total soluble solids (using refractometer), lactic acid levels determined by titration using alkaline solution (Mann,s Acid Test), total protein level (micro Kejldahl method). Sensory analysis including color, acid flavor, aroma and preference was done by using scoring test. Panelists used were trained panelists consisting of 20 people. The scoring is on a scale of 1 to 5.

2.4. Analysis of data

Data analysis was done by using simple linier regression method and descriptive analysis.

3. Result and discussion

3.1. Viability of lactic acid bacteria

According to [8], Lactobacillus is a potential lactic acid bacteria (BAL) to make food to be functional. At first, the amount of BAL was 7,573 log CFU/ml, which fulfilled the minimum requirement of probiotic food. According to [9], the total minimum of BAL in probiotic food is 6 log CFU/g at expiration time.

During the storage, BAL decreased slightly from 0.67 to 0.86 log cycle. Until the 21st day, the amount of BAL still met the minimum requirement of probiotic food, in which the lowest was 6.407 log CFU/ml (Figure 1). The decrease of BAL during this storage was better than [5] result in which BAL of yoghurt decreased as much as 2.34 log cycles during the 28 days storage time. The decrease viability of lactic acid bacteria is caused by the excessive production of acids resulting in the lactic acid bacteria death. Meanwhile, according to [10] the more total BAL exists in food, the tighter the competition among BAL will be. It means that the more total BAL in food will decrease the availability of nutrients and the BAL survival. So, the longer the storage time, the number of BAL will decrease.

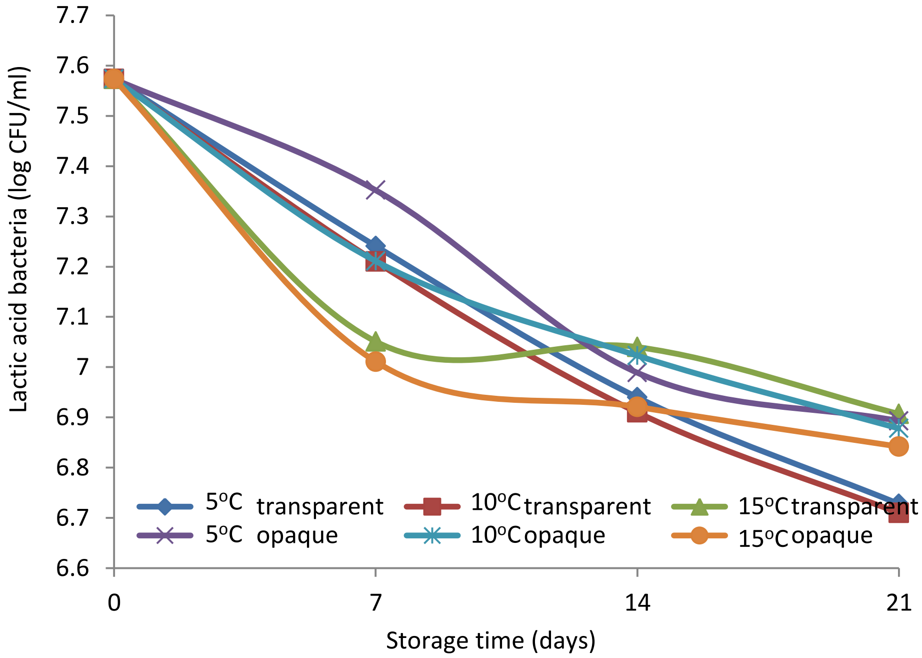

Figure 1. The number of lactic acid bacteria in corn yogurt using transparent and opaque packaging

The amount of lactic acid bacteria in yogurt using transparent and opaque packaging tended to be the same during the storage. According to [4], the ability of bacteria to grow and develop is influenced by the nutrition and environmental conditions. Nutrition that can be used by BAL to survive is proteins, fats and minerals (calcium, phosphorus and magnesium), of which have the same amount.

3.2. Protein content

During the storage, the protein content of corn yoghurt tended to decrease until the 7th day, after that, it tended to increase until the 21st day. The protein levels decreased until the 7th day because Lactobacillus was proteolytic, breaking proteins into simple peptides which was decreasing the protein levels.

Protein levels which tended to increase after the 7th day were likely because the protease enzymes degraded the proteins in microbes. Microbes are composed by various components, including 60-70% of protein. According to [11], microbial cells lysis during the storage. The protease and peptidase enzymes will break the protein down in the BAL, so the more cells lyse, the higher the protein level in yoghurt. This protein changes pattern is almost the same for transparent and opaque polypropilene packaging yogurt during the storage, but for yoghurt which was stored at the highest temperature (5°C), the protein level tends to be higher.

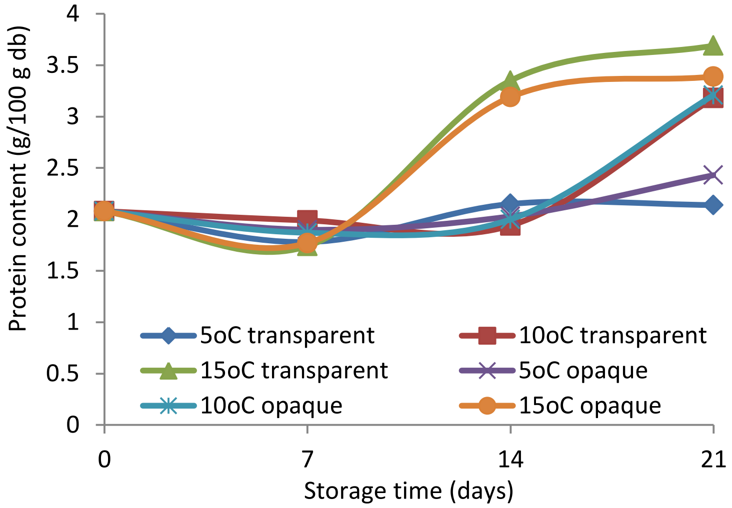

Figure 2. The protein content of corn yogurt was packaged by transparent and opaque polypropylene during the storage

3.3. Total acid and pH

The most produced organic acids in yogurt and as the main product is lactic acid [12]. During the storage, total acids in each packaging and temperature tended to increase, initially from 0.765 to 0.819-1.026 (Table 1). This shows that the production of lactic acid in corn yoghurt had increased during the storage. This is similar to [5] result in which during the 21 days storage, lactic acid levels increased to 1.11 until 1.42%. [13] also almost the same, in which during the 21 days storage, the total acidity of yogurt is 1.

According to [11], lactic acid bacteria has the optimum temperature to produce acids at 10-40°C. At 10°C and 15°C, the production of lactic acid approaches the optimal temperature of lactic acid bacteria activity so that the production of lactic acid increases. This corn yogurt also fulfill the standard of yoghurt SNI no 01-2981-1992 which has total acid of 0.5-2.

Table 1. The pH and total acid of corn yogurt was packaged by polypropylene during storage

Packaging	Storage temperature	pH on the day				Total acid on the day (%)			
		0	7	14	21	0	7	14	21
Transparent	5	4.4	4.5	4.5	4.7	0.765	0.774	0.882	0.882
	10	4.4	4.4	4.4	4.6	0.765	0.819	1.053	0.999
	15	4.4	4.5	4.5	4.6	0.765	0.81	0.882	0.918
Opaque white	5	4.4	4.5	4.5	4.6	0.765	0.783	0.864	0.819
	10	4.4	4.4	4.4	4.6	0.765	0.837	0.927	1.026
	15	4.4	4.5	4.5	4.6	0.765	0.747	0.963	0.945

Lactic acid produced during the fermentation can increase the acidity or decrease the pH. In this research, there was no decrease in pH, instead the pH increased (Table 1). On the 21st day, the pH which was originally 4.4 became 4.6-4.7. This was due to the delayed growth of lactic acid bacteria and the growth of proteolytic and other lipolytic organisms which have the ability to perform lactic acid metabolism and therefore produced base compounds. The increase of pH of yoghurt during the storage is also consistent with [14] which stated that the pH of yogurt stored in cold temperatures (4 ± 1°C) tends to increase during the storage. The initial value of pH which was 3.2 rose to 3.5 on the 10th day and 3.8 on the 35th day.

[15] reported that increasing the total acid in yogurt does not always lead to a decrease in pH. [4] also reported that a low storage temperature can inhibit the action of lactase, leading to a reduction in lactic acid production and no decrease in pH.

The production of lactic acid was increased during storage. This is consistent with [5], who found that the lactic acid content of corn yogurt increased from 1.11 to 1.42% during 21 days of storage. [13] also reported that on the 21st day, the total acidity of corn yogurt was 1%.

3.4. Total solid and viscosity

During the storage, total solids of corn yoghurt decreased slightly as shown in Table 2. The total solids of corn yoghurt was initially 23°Brix, and on the 21st day it became 22-22.7°Brix. This total decrease of solids is similar to [13] that during the storage, the total solids of yoghurt decrease. Despite the decreases during the storage, this total soluble solids still fulfil the SNI of yogurt standard of at least 8.2°Brix.

Table 2. Total solid and viscosity of corn yogurt was packaged by polypropylene during storage

Packaging	Storage temperature	Total solid at day (°Brix)				Viscosity at day (cP)			
		0	7	14	21	0	7	14	21
Transparent	5	23	23	23	23	160	190	170	160
	10	23	23	23	22,7	160	160	180	140
	15	23	23	23	22,7	160	170	180	140
Opaque white	5	23	23	23	22,5	160	180	180	200
	10	23	23	23	22	160	150	180	190
	15	23	23	23	22,6	160	150	180	160

The desired viscosity of yogurt is viscous liquids and homogeneous consistency. According to [16], the viscosity of yogurt is also influenced also by milk protein, which is casein. At pH close to 4.6, the solubility of casein is lost therefore the hydrophobic interaction occurs between the casein forming the structure and the main consistency of yogurt, and the process may affect the physic of yogurt, such as texture, viscosity, water holding capacity, and syneresis.

Casein is coagulated as the degree of acidity decreases due to the production of lactic acid. Lactic acid can agglomerate milk protein, sweet corn protein or mungbean protein. [16] explained that lactic acid leads to the change of casein/phosphate complexes to be soluble fraction of calcium and phosphate so that the casein destabilizes.

During the storage, there is increased yoghurt viscosity due to the increase of lactic acid. This can be seen from yogurt which was stored in opaque packaging until the 21st day and transparent packaging until the 14th day. It is caused by syneresis or separation of whey causing unstable curd. Syneresis can occur due to high storage temperatures, low total solids in milk, and no vibration during transport or during storage. Syneresis occurred because the transparent packaging can be penetrated by light that disrupts the stability of yogurt.

At the end of storage, the opaque packaging corn yoghurt has a higher viscosity than the transparent packaging. Storage was done in the refrigerator which has light bulb which directly highlights the product. During the storage, there is increased yoghurt viscosity due to the increase of lactic acid. This can be seen from yogurt which was stored in opaque packaging until the 21st day and transparent packaging until the 14th day. It is caused by syneresis or separation of whey causing unstable curd. Syneresis can occur due to high storage temperatures, low total solids in milk, and no vibration during transport or during storage. Syneresis occurred because the transparent packaging can be penetrated by light that disrupts the stability of yogurt.

Yogurt is required to have the form of a viscous fluid, with a homogenous consistency. According to [17], the viscosity of yogurt is also influenced by milk protein, i.e., casein. At a pH of approximately 4.6, casein becomes insoluble, resulting in hydrophobic interactions between casein micelles that form the main structure and consistency of yogurt. This process can influence the physical properties of yogurt, including its viscosity, water-holding capacity, and syneresis.

Casein is coagulated when acidity decreases due to lactic acid production. Lactic acid can agglomerate protein in milk, corn, or mungbean. [17] explain that the production of lactic acid resulted in a complex change whereby casein–phosphate was converted into soluble calcium and phosphate, with the casein being destabilized.

3.5. Sensory properties

The yoghurt quality is determined by texture or viscosity, the degree of acidity and flavor which is highly influential on sensory quality and consumer acceptance. Sensory analysis done included color, flavor, aroma and overall acceptance.

Corn yoghurt is yellow due to the presence of carotenoids. Color changes also occur because of oxidation reactions which can cause changes in flavor, color, and microbial growth in large quantities which also can damage the color or appearance of food.

Color is an important food attribute and becomes the first characteristic seen by consumers. The color of yoghurt according to the panelist assessment is 4.97 (yellow). Yellow color in yoghurt is caused by the presence of carotenoids in corn and sweet potatoes. The longer the storage, the more decrease the carotenoid color pigment will be. This is due to the degradation of pigments carried out by lactic acid bacteria. According to [16] the color changes of the fermentation medium which is getting faded after the fermentation can be caused by anthocyanin pigment degradation due to the decrease of acidity (pH) during the fermentation process. Yogurt which packaged by white opaque polypropylene was more yellow (4,2-4,35) than yogurt which packaged by transparent polypropylene (4.15) as shown in Table 3.

The formation of lactic acid in yogurt resulted in sour taste. The panelist rate on the yoghurt sour taste at the beginning of storage was 3.98 (acid), and at the end of the storage range at 3.95 (sour) to 4.4 (very sour). According to [18] the sour taste characteristic of yogurt is due to their lactic acid. The increased acid taste during storage in accordance with [13] that sour taste during the storage increased because the amount of lactic acid increased.

The panelist assessment of yogurt aroma indicated that yogurt aroma decreased during the storage. At first, the aroma value was 4.85 and at the end of the storage (the 21st day) it decreased to 3.5 - 4.35. This is caused by alcohol formed as the result of further degradation of lactic acid during the storage. According to [5], this is considered to be due to a contamination of fermentative yeast that will form alcohol during the storage.

According to [18], flavor yogurt compounds consists of 1) non-volatile acids (lactic acid, pyruvate or succinate); 2) volatile acids (formic acid, acetate, propionate or butyrate); 3) carbonyl compounds (acetaldehyde, acetone, or diacetyl), and 4) other compounds (amino acids and compounds formed by thermal degradation of proteins, fats or lactose). Among these compounds, acetaldehyde and diacetyl is the most predominant in determining the scent of yoghurt. According to [5], acetaldehyde and other carbonyl compounds will decrease during the storage of yoghurt products. In addition, during the storage, there may be oxidation so that the volatile compounds evaporate. This results in the decrease of yoghurt aroma during the storage.

Table 3. Sensory properties of corn yogurt was packaged by polypropylene during storage

Sensory attributes	Packaging		Day			
			0	7	14	21
Color	Transparent	5	4.97	4.4	4.35	4.15
		10	4.97	4.4	4.1	4.1
		15	4.97	4.35	4.1	4.1
	Opaque white	5	4.97	4.45	4.35	4.3
		10	4.97	4.4	4.4	4.35
		15	4.97	4.25	4.25	4.2
Flavour	Transparent	5	4.85	4.4	4.5	4.35
		10	4.85	3.85	3.75	3.75
		15	4.85	4.05	4	3.95
	Opaque white	5	4.85	4.3	4.25	4.15
		10	4.85	4.45	3.55	3.5
		15	4.85	4.35	3.85	3.7
Taste	Transparent	5	3.98	3.85	4.15	4.2
		10	3.98	3.95	4	4.15
		15	3.98	3.8	3.9	3.95
	Opaque white	5	3.98	3.8	4.05	3.95
		10	3.98	3.7	4.05	4.25
		15	3.98	3.75	4.2	4.4
Overall acceptance	Transparent	5	4.78	4.5	4.1	3.85
		10	4.78	4.4	3.3	3.15
		15	4.78	4.35	3.75	2.7
	Opaque white	5	4.78	4.55	4.15	3.85
		10	4.78	4.65	4	3.3
		15	4.78	4.5	3.2	2.85

Panelists' preference on yogurt is affected by several factors, including flavor, aroma, and consistency. According to [18] the preference on yoghurt is much related to the fermentation by lactic acid bacteria which resulted in a distinctive flavor of yoghurt. The stability of yoghurt also affects the preference, which can be seen from no occurrence of yoghurt damage in the form of wheying off or syneresis. According to [5] moderate viscosity and subtle texture are preferred by consumers.

The longer the storage time, the more decrease the panelists' preference judgment on yogurt is. At first, panelist's preference on yogurt was 4.78 and after storage for 21 days, panelists' preference on yogurt was 2.7-3.85 (Table 3). In metabolism reactions, the acid will turn into alcohol so that other aromas which arise are the result of the process. This is also reason of the decrease preference of panelists' preference on yoghurt.

4. Conclusion

During corn yogurt storage, the protein content decreased, while the total acid, pH, viscosity, and total solids remained consistent for both types of packaging at all three temperatures tested. At the end of storage, the amount of lactic acid bacteria still fulfil the minimum requirements of a probiotic food, with a count of 6.407 log CFU/g. Panel ratings of sensory variables tended to decrease as the length of storage increased. Corn yogurt was rated by a sensory assessment panel, and scores ranged from 0 to 5, with a mean rating of 4.78 at the beginning of storage. By the 21st day of storage, these ratings had decreased, with yogurt stored in transparent packaging having a rating of 3.85, and that stored in opaque white packaging having a value of 3.95.

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