The effect of packaging type and storage temperature on the characteristics of cheese spread analogues from corn extract

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The effect of packaging type and storage temperature on the characteristics of cheese spread analogues from corn extract

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Abstract. Cheese spread analogues composed of corn milk have a limited shelf life due to their high water and fat content. Therefore, appropriate packaging and storage temperatures are required to maintain the nature of these products for long-term storage. The purpose of the present study was to 1) study the effect of packaging type and storage temperature on the chemical and sensory characteristics of corn milk-based cheese analogues; 2) determine the most effective packaging type for corn milk-based cheese analogues; 3) determine the optimal storage temperature to be applied for corn milk-based cheese analogue. The present study used a completely randomised split-plot design. The effects of various storage factors were assessed, including storage time (1, 2, 3 and 4 weeks) as the main plot, type of packaging (polypropylene, polyethylene terephthalate, and glass) as a subplot, and storage temperature (-5°C, 5°C, and 10°C) as a subplot. The studied cheese analogue variables included moisture, free fatty acid content, soluble protein content, fat content, pH and sensory characteristics. The results indicated that packaging type and storage temperature had a significant effect on analogue cheese during storage. The most effective packaging types applied for 4 weeks of analogue cheese storage were glass packaging with a moisture content of 69.60%, soluble protein of 6.91%, a fat content of 5.4%, free fatty acid content of 3.65% and pH of 4.6. The sensory characteristics included smooth texture, easy to spread, a bright, attractive and shiny appearance, pale yellow colour, and acidic smell. The optimum storage temperature for corn milk-based analogue cheese spread for 4 weeks was 5°C with a moisture content of 69.26%, dissolved protein content of 7.23%, fat content of 5.68%, free fatty acid content of 3.54% and pH 4.6. Sensory characteristics included smooth texture, easy to spread, a bright, attractive and shiny appearance, pale yellow colour, and slightly acidic smell smelling only slightly of cheese.

Keywords: cheese analogues, corn, glass packaging

1. Introduction

Cheese spread analogues can consist of milk or non-milk protein while substituting oil or milk fat or milk solids [1]. One ingredient that can be used to make cheese spread analogue is corn milk [2]. As per cheese in general, cheese spread analogues have a high water content; thus, they can easily become damaged [3].

Packaging strongly influences changes in product quality during storage. Some types of packaging materials can be used to package corn milk-based cheese spread analogues, include polypropylene (PP), polyethylene terephthalate (PET), and glass. PP packaging is strong, transparent but not clear, has a light mass, waxy surface and is resistant to chemicals, heat and oil [4]. PET packaging has a light mass, is clear, transparent, strong, solvent resistant and impermeable to gas and water; however, it softens at 80°C [5]. Glass packaging has the advantages of not reacting with packaged materials, being resistant to acids, bases and the environment, being made transparent or dark, being odourless; however, glass has a heavy mass and is easily broken [6].

Storage temperature also affects the deterioration of product quality and must be stably maintained to prevent the loss of quality during storage [7]. The temperature that can be used to store cheese spread analogue is low, as low temperatures are intended to slow down the speed of metabolic reactions and inhibit chemical reactions as well as enzymatic or microbial growth.

The present study aims to 1) determine the most effective type of packaging for corn milk-based cheese spread analogue and to 2) determine the optimum storage temperature for corn milk-based cheese spread analogue.

2. Materials and methods

The main ingredients used in the present study included sweet corn sourced from Wage Market, Purwokerto, Central Java, Indonesia; whey protein isolate (Global Milk Specialties), Arabic gum, Tween 20, virgin coconut oil (Mutia, Yogyakarta) and other ingredients. The main equipment used included a blender, filter, PET plastic packaging, PP plastic packaging, glass packaging, a refrigerator, a freezer, and a set of analysers.

Cheese spread production was performed using a modified [2] method. Corn was steam blanched for 30 minutes and then ground with the addition of water (1: 2). Corn extract plus 15% whey protein isolate was then heated to 70°C for 15 seconds. The corn extract was then added by 7.5% VCO and 0.5% Tween 20, then stirred and allowed to stand for 5 minutes. The next step involved pressing for 15 minutes. The solids obtained were then combined with 6% sugar and 1% salt. The obtained cheese was then heated to 40°C for 15 seconds. The resulting analogue cheese was then packaged using polypropylene, polyethylene terephthalate and glass packaging and stored at -5, 5 and 10°C. Furthermore, an analysis of water content, fat content, free fatty acid (FFA) content, dissolved protein content, pH and organoleptic tests were performed every week for 4 weeks.

The study used a split-plot design involving a completely randomised design (CRD). The assessed factors included 1) storage time as the main plot (1 week, 2 weeks, 3 weeks and 4 weeks); 2) types of packaging as subplots (PP packaging, PET packaging, glass packaging); and 3) storage temperature as subplots (-5°C, 5°C, and 10°C). Data were analysed using the analysis of variance (ANOVA) test; if a significant effect was observed, Duncan's Multiple Test (DMRT) at a 5% confidence level was performed. The organoleptic test results were analysed using the Friedman test; if this test had a significant effect, it was followed by a multiple comparison test with a significant level of 5%.

3. Results and discussion

3.1. Moisture content

The moisture content of cheese spread analogues increased over storage time, with the lowest moisture content being observed a storage time of 1 week (68.29%) and the highest at 4 weeks (69.48%). This increase in water content can be predicted using the equation $y = 0.397x + 67.905$ with $R^2 = 0.999$ (Fig. 1). According to the United States Department of Agriculture (2001), the water content of soft cheese is no more than 80%. When viewed from the prediction equation, the water content of cheese spread analogue can be stored for up to 30 weeks, with water content reaching 79%.

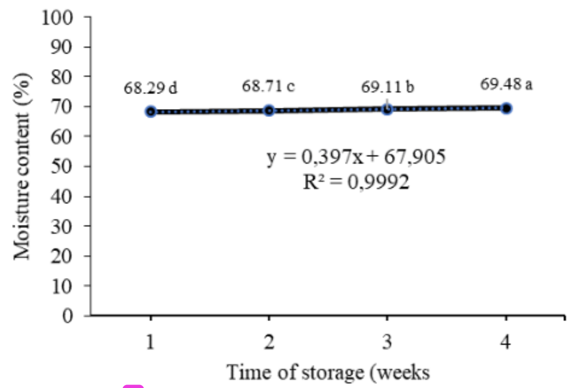

Figure 1. The moisture content of cheese spread analogue during storage

The increased moisture content of cheese spread analogues during storage is likely due to the product absorbing water from the environment. High humidity in storage rooms can cause the process of water vapour absorption from the air to the product, resulting in increased water content [8]. The increased water content during storage is in accordance with [9], who stated that the moisture content of cheese spread analogues tends to increase during storage. In food products, increased water content can cause damage and affect shelf life [4].

3.2. Dissolved protein content

Packaging type, temperature and storage time significantly influence the level of dissolved protein. The dissolved protein content of cheese spread analogues in glass packaging (7.5%) was higher when compared to cheese spread analogues in PP (7.39%) and PET (7.26%) packaging (Fig. 2). This is due to PP and PET packaging having higher permeability, thus absorbing more air from the storage environment when compared to glass packaging. According to [10], glass packaging is impermeable, whereas polypropylene and polyethylene packaging have water vapour permeabilities of 6.8 $g/m^2/24$ hours and 1.3 $g/m^2/24$ hours, respectively. Air contact with cheese spread analogues triggers fat oxidation, causing the fat contained therein to become damaged. This causes cheese spread analogues to become acidic, thereby resulting in protein denaturation [11]. Acid or base reagents can break the intermolecular hydrogen bonds that cause protein coagulation [9]. If the protein is in long-term contact with acids or bases, it is very likely that the peptide bonds will be hydrolysed, which results in the primary protein structure to become completely damaged. Protein damage causes proteins to lose certain properties (e.g. solubility).

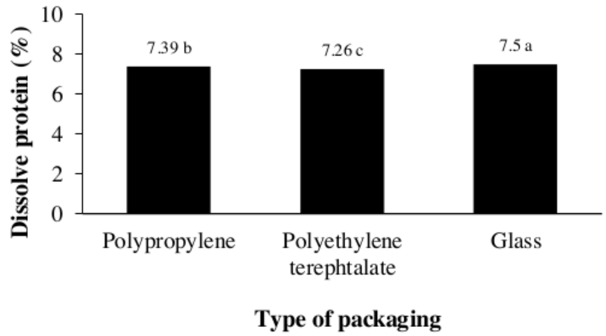

Figure 2. The dissolved protein content of cheese spread analogue stored in three types of packaging

The highest dissolved protein content was observed at a storage temperature of 5°C (7.73%), while the lowest value was observed at 10°C (7.17%) (Fig. 2). This result is due to the higher temperature of more rapid fat hydrolysis and the production of more free fatty acids; therefore, the protein contained in cheese spread analogue will be denatured due to the acidic environment. This is consistent with [9], who stated that the higher the storage temperature, the greater the number of molecules with greater kinetic energy, thus making the particles involved in the reaction move faster. The movement of particles involved in this reaction causes damage to fat and turns into free fatty acids so that the product becomes acidic and causes denatured proteins.

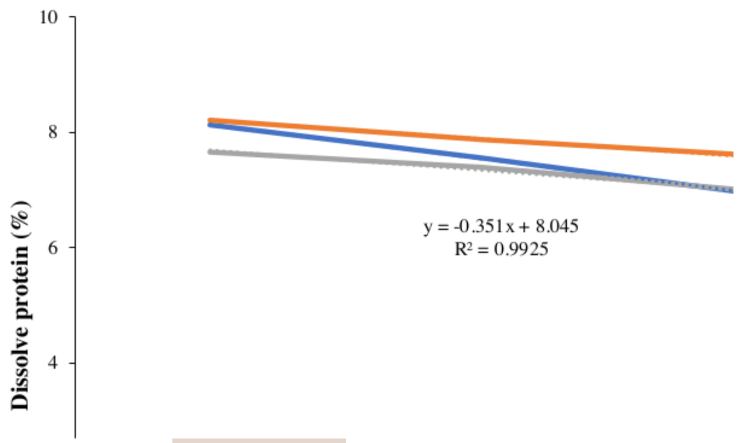

Figure. 3. The dissolved protein content of cheese spread analogues during storage at different temperatures

Cheese spread analogues exhibited decreased levels of dissolved protein during the storage process at all temperatures. This is because protein decomposition and hydrolysis occur during storage, resulting in the levels of dissolved protein decreasing over time. A decrease in the highest levels of dissolved protein (found at -5°C) can be observed from the sharp linear regression graph (Fig. 3). This is presumably because ice crystals will form at a temperature of -5°C, which can damage the protein membrane and cause protein solubility to decrease. According to [12], the freezing process causes damage to the function and structure of the membrane, which is caused by the formation of intracellular ice crystals that can damage protein cells. A decrease in the lowest dissolved protein content occurred at 5°C, where it still had a dissolved protein content of 7.23% at 4 weeks of storage time. This is in accordance with [13], who noted that soft cheeses should be stored at 5-10°C to inhibit and prevent cheese damage from microbial contamination, fat hydrolysis and protein denaturation, which can reduce cheese quality and make cheese storage low.

3.3. Fat content

Storage temperature, storage time and packaging type significantly affected the fat content of cheese spread analogue. The fat content of cheese spread analogue decreased with increasing storage temperature, following a linear regression with the equation y = -0.02x + 6.33 (Fig. 4). Thus, higher temperatures increase the potential for fat hydrolysis. With higher storage temperature, the number of molecules having greater kinetic energy makes the particles involved in the reaction move faster. The movement of particles involved in this reaction causes damage to fat and turns it into free fatty acids, resulting in decreased fat content [14].

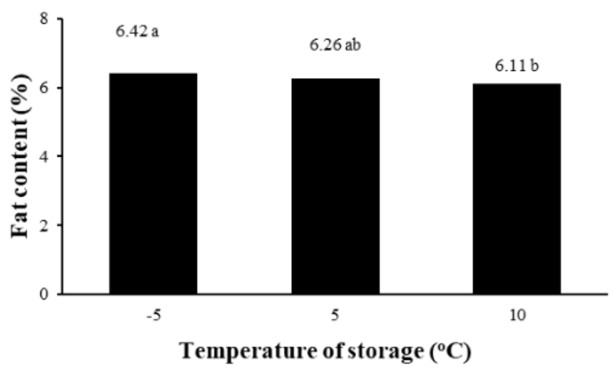

Figure 4. The fat content of cheese spread analogue at different storage temperatures

In all types of packaging, the fat content of cheese spread analogue decreased during the storage process. This is because, during the storage, the fat in cheese spread analogue undergoes hydrolysis, which causes the triglyceride molecular bonds to break and turn into free fatty acids. Moreover, the rupture of triglyceride molecular bonds causes the fat content to decrease and free fatty acid level to rise.

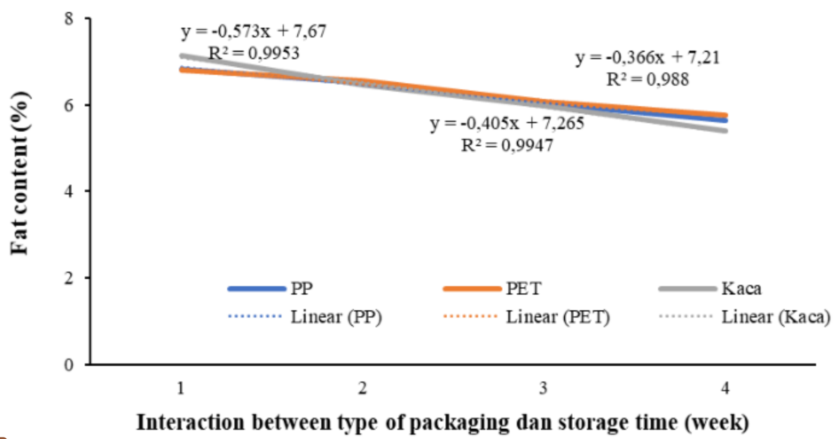

Figure 5. The fat content of cheese spread analogue during storage on several types of packaging

Cheese spread analogue packaged in glass has the highest reduction in fat content compared to other packaging types, which is evident from its linear regression equation (Fig. 5). This is likely because glass packaging is impermeable to air, with trapped air triggering more rapid fat hydrolysis. This results in the fat content of cheese spread analogue packaged in glass being lower than the same product stored in other types of packaging. This is in accordance with [15], who noted that probiotic products packaged in glass bottles have the highest increase in water content compared to other packages since this packaging is airtight and translucent. The air contained in a glass bottle will increase the water content of the product due to light transmitted from outside the packaging. This increased water content will accelerate the reaction of fat hydrolysis. The fat content of cheese spread analogue stored for 4 weeks is lower when compared to the fat content of cheese in general, where 100 grams of cheese contains 20.3% fat [16].

3.4. Free fatty acid content

The highest FFA levels were observed in cheese spread analogue packaged in PET (3.43%), while the lowest was observed in spread cheese analogue packaged in glass (3.39%) (Fig. 6). This is because glass packaging has the ability to prevent the transmission of water vapour to the product better than the other two packaging materials. According to [17], glass packaging has a water vapour transmission rate of <0.01 $g/m^2/day$, which is lower than that of PP (<10 $g/m^2/day$) and PET (100 $g/m^2/day$) packaging. Water vapour absorbed into food products can cause fat hydrolysis, causing fat to break down into free fatty acids.

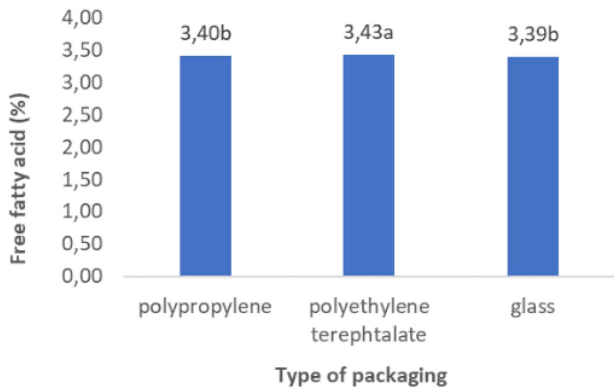

Figure 6. The free fatty acids of cheese analogue using different packaging types

Notably, cheese spread analogue stored at 10°C had higher FFA levels compared to the same product stored at -5 and 5°C. This is because the higher the storage temperature, the faster the chemical reaction occurs, which results in more rapid hydrolysis reactions. This is in accordance with [9], who noted that the higher the storage temperature, the greater the number of molecules having greater kinetic energy, thus making the particles involved in the reaction move faster. Higher temperatures also cause chemical damage reactions in food products to occur faster, while hydrolysis reactions can be accelerated with high temperatures as a catalyst [18].

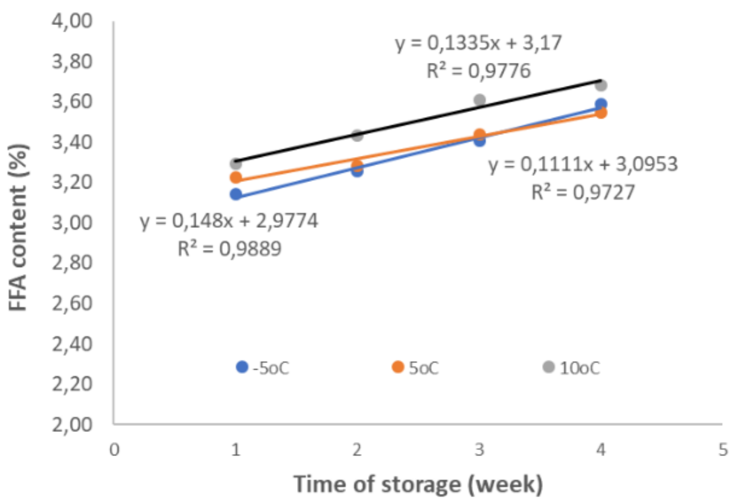

Figure 7. The free fatty acids of cheese analogue during storage at different temperatures

A previous study has noted that the maximum limit of free fatty acids in gruyere cheese products is 4.38% [19]. Based on these standards and the predictions using linear regression in Fig. 7, cheese spread analogue stored at -5, 5 and 10°C can be maintained for 8, 10 and 8 weeks, respectively.

3.5. Organoleptic characteristics

The texture, appearance, colour and flavour of cheese spread analogue decreased during storage. Cheese analogue packed in PP and stored at 10°C (K1S3) exhibited the lowest texture value (4.2) at the end of storage (slightly smooth, lumps present, rather easy to spread). Cheese analogue packed in PET and stored at 5°C (K2S2) exhibited the highest texture value (5.6) at the end of storage (smooth, slightly lumpy, easily spread).

Changes in cheese spread analogue texture during storage are due to protein denaturation, which is marked by the appearance of lumps. This result is consistent with [20], who noted that denaturation can change protein properties. Changes due to denaturation are due to decreased enzyme or hormone activity, salt or acid solubility, crystal formation ability and clot formation stability.

The appearance of cheese analogue also decreases during the storage period. Cheese analogue in PP packaging stored at 10°C (K1S3) had the poorest appearance value (4.3) at the end of storage (slightly mouldy, less attractive, slightly shiny). Cheese analogue stored in glass packaging at 5°C (K3S2) had the best appearance value (5.4) at the end of storage (nearly mouldy, quite attractive, rather shiny).

The growth of fungi during storage is caused by the water content held by corn milk-based cheese analogue, which is relatively high and increases during storage [21]. Notably, high water content can support the growth of microorganism, while water activity in food affects the resistance of food to microbial attack.

The colour of cheese analogue decreased during the storage period. Cheese analogue stored in PP at 10°C (K1S3) had a lower colour value (4.5) compared to other treatments at the end of storage (yellow slightly speckled with green, less attractive, slightly dull). Meanwhile, cheese analogue in glass packaging stored at 5°C (K3S2) had a higher colour value (5.6) compared to other treatments at the end of storage (nearly mouldy, quite attractive, rather shiny).

The aroma of analogue cheese decreased during storage. Analogue cheese stored at 10°C in PET (K2S3) had a lower aroma value (3.9) than other treatments at the end of storage (very acidic, rancid). However, cheese analogue packaged in glass and stored at -5°C (K3S1) and 5°C (K3S2) had the same aroma value (5.4) at the end of storage, which is higher compared to other treatments (slightly acidic, slight cheese aroma).

The most effective packaging type for cheese analogue is glass packaging. At the end of a 4-week storage period, cheese analogue stored in glass exhibited better chemical and organoleptic characteristics when compared to other types of packaging, namely 69.60% moisture content, 6.91% dissolved protein content, 5.4% fat content and an FFA level of 3.65%. The organoleptic characteristics included a fine texture with small lumps, easy to spread, nearly appearing mouldy, bright, attractive, rather shiny, pale yellow colour, and has an acidic odour that is slightly rancid and does not smell like the distinctive aroma of cheese.

The optimum storage temperature for spread cheese analogue is 5°C, which has better chemical and organoleptic characteristics after a 4-week storage period compared to other storage temperatures (69.26% moisture content, 7.23% dissolved protein content, 5.68% fat content and 3.54% FFA level). Its organoleptic properties include a fine texture with small lumps, easy to spread, appearing almost non-mouldy, attractive and rather shiny pale-yellow colour, somewhat bright, and slightly acidic aroma with only a slight cheese aroma.

Analogue cheese remains suitable for consumption after up to 4 weeks of storage, with a water content of 68.71%, dissolved protein content of 7.62%, fat content of 6.50%, FFA content of 3.32% and pH of 4.8. Moreover, its texture is smooth, slightly lumpy and easily spread, with an appearance of being nearly mouldy, attractive and rather shiny, pale yellow, and bright with a slightly acidic aroma and only a slight cheese aroma.

4. Conclusion

Glass is the most effective type of packaging for the storage of corn milk-based cheese spread analogue, which has better chemical and organoleptic characteristics after a 4-week storage period compared to other types of packaging. The optimum storage temperature for corn milk-based cheese spread analogue is 5°C, which has better chemical and organoleptic characteristics which after a 4-week storage period when compared to other storage temperatures.

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Purwokerto, November 11, 2019

LETTER OF ACCEPTANCE

Dear.
Nur Aini
Universitas Jenderal Soedirman

Herewit 4 the international committee is happy to inform you that the peer-reviewed draft paper entitled **The Effect of Packaging Type and Storage Temperature on the Characteristics of Cheese Spread Analogues from Corn Extr 10** has been accepted for oral presentation as well as inclusion in the conference proceeding of the 2nd International Conference on Multidisciplinary Approaches for Sustainable Rural Development (ICMA-SURE), to be held in Java Heritage Hotel, Purwokerto, Central Java, Indonesia during November 19-20, 2019.

We are looking forward to seeing you in Purwokerto.

ICMA-SURE Chair

Dr.Eng. Muhtar Effendi

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