ORIGINAL ARTICLE

Development and Evaluation of Processed Cheese Spread Supplemented with Ripened Cheddar Cheese

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A B S T R A C T

In this research, processed cheese spread was prepared with various concentrations of ripened cheddar cheese. The ripened cheddar cheese addition in fresh cream cheese improves the color, texture, flavor and to make more nutritious product. Cheese spread was developed by treatment of 5, 10, 15 and 20% of ripened cheddar cheese addition in fresh cream cheese by using emulsifiers (distilled monoglycerides), melting salts (tri-calcium phosphate), preservatives (Nisin and potassium sorbate), heating and shear mixing. The effect of ripened cheddar cheese on its physicochemical properties (pH, ash, moisture content, acidity, crude protein, and fat content, texture profile analysis (TPA) and organoleptic analysis such as texture, color, spreading ability, the flavor of the product was studied. The variability in pH, fat, protein, moisture and ash of processed cheese spread; treatments and storage were significant ($P \leq 0.05$) whereas their interaction effect was significant ($P \leq 0.05$). Similarly, sensory attributes (texture, color, spreadability, flavor, overall acceptability) were affected significantly by treatments. The texture profile analysis (firmness, adhesiveness and spreadability) also had a highly significant effect on the treatments and storage. The panelists preferred T_3 sample comprising of 15% ripened cheddar cheese due to better texture, color, spreadability, flavor and overall acceptability. It has benefits; economical, highly nutritious and greater shelf life as compared to fresh cream cheese. Cheddar is a popular cheese all over the world because of its distinct flavor characteristics that matured during the ripening period. The sensory attributes and nutritional profile improved with unique flavor of buttery cheddar flavor.

Keywords: Flavor Enhancement, Ameliorate Shelf Life, Cheese Spread Nutrition, Ripened Cheddar Cheese.

1. INTRODUCTION

Cheese has long been a part of the human diet. The healthy fat and protein volume made it an energy dense, nutritious and source of milk with the advantage of extended shelf life.

Cream cheese is a fresh cheese produced from cream or a mix of cream and milk using acidic a bacterial culture and rennet as a coagulant. Cream cheese must have a minimum fat percentage of 33% and a maximum moisture percentage of 55% (FDA, 2015). Cream cheese has a buttery, smooth and spreadable texture, a smooth thickness, a white to slightly yellowish color and a moderately acidic, diacetyl-flavored aroma. Codex Alimentarius defined cream cheese as the spreadable, un-ripened, rind-less, smooth and soft in texture.

Cream cheese texture is determined by processing parameters such as homogenization, pH, treatment temperature following fermentation, basic composition (mainly the protein and fat content), moisture content and salt or stabilizer addition. As the fat %age in cream cheese is lowered, the proportion of protein and moisture increases, but yield decrease. The fat level of cream cheese also controlled its hardness and spreading ability; a larger fat content produced the cheese more spreadable while reducing its firmness and stickiness. As the fat level of cream cheese dropped, the adhesiveness of the cheese improved. Adhesiveness describes the sticky characteristics of food items.

Cream cheese is a diverse dietary product since it may be flavored and spiced, as well as has hydrocolloids and gums added to give it varied physical and sensory qualities. However, because of its high moisture and fat content, it has a limited shelf life and must be stored in a refrigerator most of the time (Shirashoji *et al*., 2006). The fat percentage of cream is standardized in proportion to the casein content (Pombo, 2020). Fat is linked to creaminess in liquid dairy products, according to research on sensory perception of fat in many dairies; fat takes the shape of emulsified particles that are seen as smooth and creamy (Frøst and Janhøj, 2007).

Emulsifiers and stabilizers are also important in obtaining the necessary homogeneous consistency. Cheese spread is both wholesome and premium, not only that, but cheese spread has also helped to reduce the quantity of cheese lost during the preparation process. It may be made from a variety of components with different origins and its characteristics allow it to be made in a variety of tastes (Guinee and Hickey, 2009). Processed cheese is a milk product viscoelastic gel that can also be defined: a solid oil-in-water emulsion (Lee *et al*., 2003; Chen and Liu, 2012; Hanaei *et al*., 2015). The required final smooth and homogeneous matrix of processed cheese is achieved by mixing shredded natural cheese in the presence of emulsifying salts, cooked under partial vacuum and on-going shear, typically in the range of 90–100°C.

The flexibility with which cream cheese spreads out in a thin, uniform layer on a surface is referred to as spreadability. Fat content influences key cream cheese textural characteristics such as adhesiveness, rigidity and spreadability. Electrostatic and hydrophobic, cheese proteins have poor physical connections that quickly collapse under shear stress. Due to the high moisture-to-protein ratio, the rheology of low-fat cream cheese indicated a dense protein network with reduced-fat particles dispersed over the matrix, leading to improved firmness (Ningtyas *et al*., 2017). The cheese flavor is one of the most important variables influencing customer taste and acceptability. The volatile profile is often considered to represent a picture of cheese's flavor and fragrance. As a consequence, a dynamic mix of volatile and non-volatile chemical components imparts a cheese's particular flavor (Delgado *et al*., 2010).

Cheddar is the most common cheese in the world, in both terms of production and overall consumption. When the composition of cheddar cheese is characterized as varying amounts of fat in a structurally linked protein matrix (constant moisture: protein ratio), the network loosens while adding weak spots in the form of fat-protein interactions. The weak spots generate further strain weakening and reduced fracture strain during deformation, resulting in smaller particles. As a result, during chewing, there is less hardness and more breakage (Drake *et al*., 2008). Cheddar cheese requires a longer ripening cycle to achieve optimal flavor and texture qualities. Before being marketed, cheddar cheese is matured for 06–12 months (Chopde *et al*., 2014). Methanethiol has been linked to appealing cheddar type sulfur effects in high-quality cheddar cheese. Whether used alone or in massive amounts, Methanethiol does not provide the specific cheddar cheese flavor. Significant lipolysis is required and desirable in certain cheeses as part of the overall flavor creation process; in addition, FFAs play an important role in the flavor of cheddar cheese. Short-chain fatty acids, such as butyric acid, have a high concentration of nasty off-flavors. When compared to milk fat, cheddar cheese contains a higher ratio of free caproic acid to linolenic acid. In contrast to milk fat, cheese has a greater quantity of free butanoic acid. Proteolysis is the most complicated and important main process that occurs throughout most types of cheese ripening (McSweeney and Sousa, 2000).

Ripened cheddar is a hard cheese that colors from nearly white to ivory to intense yellow or brown, also has waxy, hard, smooth and strong feelings about it. Furthermore, there is no gas hole; however, there may be gaps and cracks. Different degrees of maturity needed, the ripening time for obtaining characteristic flavor and physical attributes ranged from 05 weeks to 02 years (07–15°C) (Codex standard 263-1966; Codex Alimentarius Commission, 2013). Their flavor is moderately acidic, salty and it can become rancid and pungent as time goes on. Starter cultures and secondary or adjunct cultures are among the most important contributors to the ripening process due to their high metabolic activity (Khattab *et al*., 2019). After ripening, in brine with various salt concentrations for several days or up to several months, they are consumed (Hayaloglu, 2016).

Treatment 50% paneer had the highest marks for color and appearance, flavor and taste, body and feel and overall acceptability: 05% cheddar: 50% mozzarella (Singh and Chandra, 2017). When fresh cream cheese is mixed with matured cheddar cheese, the texture, flavor and nutritional value all improve. Additionally, it has increased antioxidant activity, which was developed during the early phases of proteolysis. Processed cheese's shelf life will be extended because of the heating method.

Cheddar cheese combinations of 2-3 month old cheddar cheese and 4-5 month old cheddar cheese were used to make processed cheese spread. Whey protein concentrate was added, which significantly enhanced the spread's rheology, especially at the 3.0 and 4.5% levels. Whey protein concentrate levels in the product were higher, softer the flavor and high melt ability, desirable features and enhanced spreading ability in quantities up to 4.5% of cheese solids (Pinto *et al*., 2007).

The combination of hydrocolloid about 2% and apple puree about 10% is used to enhance the texture of cream cheese spread and make it more nutritious. The textural properties have higher hardness and viscosity sample consists of Gelatin and carrageenan (Gulzar *et al*., 2015). When inulin was added to cheese spread fat (both total saturated and unsaturated fatty acids reduced; poly-unsaturated fatty acid increased), protein content decreased, dietary fiber content increased, compared to the control sample (Giri *et al*., 2017). Inulin, on the other hand, takes approximately 10% of the sweetness of sucrose (Tárrega and Costell, 2006).

Spreadable cheese was supplemented with by-product flours as a provider of fiber and antioxidant compounds (grape pomace, tomato peel, broccoli, grain bran and artichokes). Cheese spread having white and red grape pomace had higher phenolic content, vegetable powder considerably enhanced total phenolic content and antioxidants when compared to the control sample (Lucera *et al*., 2018).

Besides many ingredients from dairy (cream, butter, whey, milk powder and buttermilk), synthetically components (stabilizers, preservatives, flavoring agents, acidifying agents) were added as raw material (Kapoor and Metzger, 2008; Ferrão *et al*., 2016). When agitation speed rose, the final product's hardness, cohesiveness and storage modulus improved, but the particle size of fat dropped (Noronha *et al*., 2008).

The water phase viscosity of locust bean gum cream cheese decreased sharply at 25^{o} C, more than at 4^{o} C, leads to an increase in syneresis and suggesting that the stabilizer function may have been impaired over time. During storage, there were most several protein network conformational changes, producing shortening and syneresis (Kindstedt and Acosta, 2005).

The size of fat particles larger as the amount of vegetable fat used enhanced, their dispersion in the protein matrix declined. In numerous characteristics, like color, firmness and creaminess, the counterpart with 50% vegetable fat performed better than processed cheese. This demonstrates that replacing traditional processed cheese with an equivalent based on vegetable oil is a viable option (Cunha *et al*., 2010). Cheese produced with butter oil, lower melting, poor spreadability, higher hardness and higher elastic and viscous moduli values (Cunha *et al*., 2013).

Nisin is the most characterized and commercially available bacteriocin. Certain strains of Lactococcuslatis sub sp. lactis generate nisin, which has antibacterial action against spores and Gram-positive vegetative organisms like Listeria (Chollet *et al.*, 2008).

There are several reasons why processed cheese spread may be preferred over other types of cheese: 1) Convenience of processed cheese spread is easy to use and comes in a variety of flavors, making it a popular choice for quick and easy meals 2) Texture of processed cheese spread has a smooth and creamy texture, which makes it easy to spread on crackers, bread, or other foods 3) Meltability of processed cheese spread melts easily, making it a popular choice for use in recipes such as grilled cheese sandwiches or macaroni and cheese and 4) Shelf life of processed cheese spread has a longer shelf life than many other types of cheese, making it a popular choice for those who want to keep cheese on hand for an extended period.

2. MATERIALS AND METHODS

The research has been done in the Dairy Technology Laboratory, National Institute of Food Science and Technology, University of Agriculture, Faisalabad (UAF).

2.1. Procurement of Raw Material and Reagents

The required milk was obtained from the University of Agriculture Faisalabad. The rennet and freeze-dried mesophilic microbial culture for cheese from CHR HANSEN and preservatives (Potassium sorbate and Nisin), emulsifiers (Distilled Monoglycerides), stabilizers (Locust Bean Gum) and melting salts (Disodium Phosphate and Tri-Calcium phosphate) other reagents required for analysis were purchased from the official distributor of Sigma Aldrich.

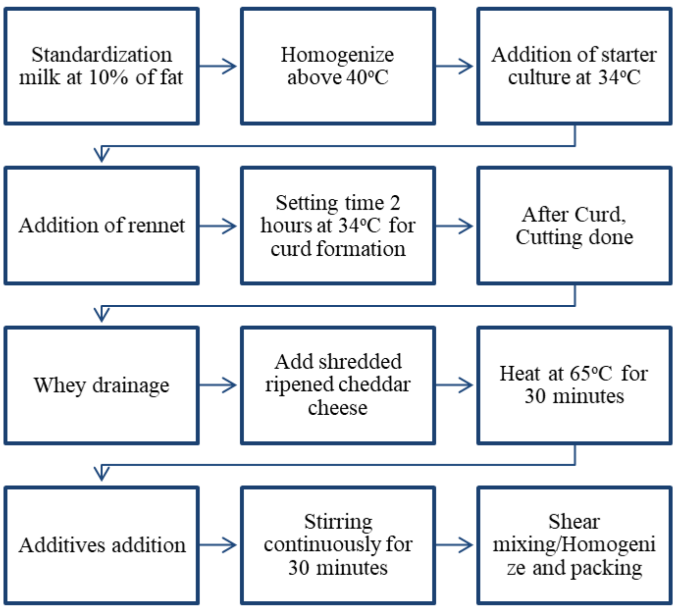

Figure 1. Flow-line for processed cheese spread supplemented with ripened cheddar cheese processing

2.2. Product Development

Preparation of processed cheese spread

First is to standardize the fat content through mixing cream and milk by using Pearson Square Method. The fat was standardized up to 10%. Then, homogenize the cream and milk to mix the fat content uniformly. Then add starter culture at the rate of 0.02% at a temperature of 34°C and after 30 minutes added rennet and set until curd formation. Scalding was performed at 45°C for 10 minutes. The fresh cream cheese left after whey drained. The fresh cream cheese was heated to 65°C whereas the shearing and mixing step was done with the help of a hand stirrer for 30 minutes while heating. During this step, emulsifiers and stabilizers at the rate of 2% of the initial weight of the sample were added meanwhile also added according to the treatment plan (Phadungath, 2005). Ripened cheddar cheese was shredded and left at room temperature for at least 30 minutes to develop flavor. The shredded ripened cheddar cheese is added into fresh cream cheese, during mixing and heating process as shown in Fig **1**.

As mentioned in Table **1**, levels of cream cheese (CC) and ripened cheddar cheese (RCC) to be used in processed cheese spread. Concentrations were added according to the following treatment plan.

Table 1. Treatment Plan for the Development Spread Cheese

Treatments	CC (%)	RCC (%)
T_0	100%	---
T1	95%	5%
T2	90%	10%
T3	85%	15%
T4	80%	20%

2.3. Physicochemical Analysis

The samples of processed cheese spread were analyzed for pH, moisture, ash, acidity, crude protein, and fat during the storage span after an interval of 0, 15, 30 and 45-day. Every experiment was performed in triplicate for control as well as other formulations and average values were documented.

Moisture analysis

Moisture analysis of the cheese spread was done by the procedure explained in AOAC method 44-15A (2016). Initially, the weight of the moisture-free china dish was noted. Next a sample of 3g was assembled inside the china dish and weighed again. The China dish with the sample was placed inside the drying oven which was set at a temperature of 105°C until the constant weight of the china dish with the sample was observed. Moisture content was computed as follows:

$$\text{Moisture (\%)} = \frac{\text{Weight of sample before drying - Weight of residue after drying}}{\text{Weight of sample before drying}} \text{X100}$$

Fat analysis

The fat content of the cheese spread was analyzed according to the technique explained in AOAC (2016). The cheese spread sample of 6g and 16mL of distilled water was mixed to make a slurry, then heat it and the sample inside the beaker continuously stirred. After that, 10mL of H_2SO_4 was fetched inside the cheese butyrometer and the 10.94mL of the slurry carefully; making a layer above the surface of H_2SO_4 and lastly, 1mL of isoamyl alcohol was added inside the butyrometer. After closing the lid of the butyrometer properly, it was shaken carefully till the cheese sample was dissolved entirely and no traces of cheese were left visible. The butyrometer was placed in the Gerber centrifuge machine and started at the set of 1100 rpm and temperature of 65°C for 5 minutes. The reading was noted from the scale on the butyrometer carefully after the centrifuge machine stopped completely.

Ash

Ash content of the cheese spread was measured by using the method described in AOAC (2016). The moisture-free sample was collected in a china dish and its charring was done to remove all the volatile compounds present in it. Then incinerate the sample in a muffle furnace at a high temperature of 550°C until the sample was completely transformed into the greyish powdered residue. The remaining residue was ash and the percentage of ash was computed as per the formula:

$$\text{Ash \%} = \frac{\text{Weight of Ash}}{\text{Initial weight}} \times 100$$

Crude protein

Kjeldahl's method was used to estimate the concentration of crude protein as described by Kirk and Sawyer (1991). A cheese spread sample of weight 1g was collected inside the Kjeldahl flask after wrapping it in butter paper. In the same way, 30mL of concentrated H_2SO_4 and one digestion tablet was added inside the Kjeldahl flask. The flask was adjusted back in the Kjeldahl's digestion apparatus and the sample was digested for 3-4 hours till the sample mixture was changed into the light green colored solution. The solution was collected in a 250mL volumetric flask and diluted with distilled water up to the 250mL mark. The distillation of the diluted sample solution from the digestion apparatus was performed in Kjeldahl's distillation apparatus. Before starting the distillation process, 10mL of 40% NaOH solution was added into the diluted sample solution to transform the nitrogen content of the sample to NH_4OH. The nitrogen was distilled and collected in the flask containing the 20mL solution of 4% boric acid. The boric acid solution containing distilled nitrogen was titrated against 0.1N H_2SO_4 and methyl red indicator drops were added in it. The amount of H_2SO_4 consumed to neutralize the ammonium hydroxide was recorded and the protein content was estimated using the formula

Nitrogen (%) =

$$\frac{\text{vol. (Sample-blank) Acid} \times \text{normality of Acid} \times 0.014}{\text{Weight of sample}} \times 100$$

Protein (%) = N (%) × 6.38

Titratable acidity

The measurement of the acidity of processed cheese spread, slurry of cheese spread was prepared by taking 1g of sample and mixing it with 9mL of distilled water. Then, titrate it with a 0.1N NaOH solution. The addition of phenolphthalein indicator and then titrate it till the light pink color appears. The acidity was measured according to the formula:

$$\text{Acidity} = \frac{\text{Vol. of 0.1N NaOH used} \times 0.009 \times 100}{\text{10 mL}}$$

pH

The pH of the processed cheese spread was analyzed using a pH meter from Hanna Instruments while following the guidelines of AOAC (2016). The electrode of the pH meter was then rinsed with a cleaning solution and its sensitive tip was submerged in the sample and triplicate reading was observed from the display screen of the pH meter.

Color analysis

A mini-scan portable colorimeter was used to analyze the cheese spread samples. Calibration of the colorimeter was done using standard black and white plates. Cheese spread samples were placed. Samples were scanned by the colorimeter and the values were given by using CIE (1978) L*, a* and b* values. The value denoted by a* scale indicates green (+) and red (-) hue whereas b* scale value shows the blue (+) and yellow (-) hue and lastly, L* value shows lightness and darkness (Morsy *et al*., 2015).

2.4. Textural Analysis

By using texture analyzer, texture analysis of processed cheese spread was done followed by the method described in AOAC (2016). Texture analyzer was attached with computer (stable micro system, UK, Surrey and Mod TA-XT2) which holds the instrument and showed the recorded data. To check the hardness of cheese (Chen *et al*., 1979), texture determination was done by using 3-point binding ridge for bend test. Under 3-point binding ridge, bending on heavy duty platform was done by placing the sample at central area. Texture Expert program with the version of 1.21 was used for the treatment of texture data. Repeated measurements were observed by the mean value of every formulation.

2.5. Sensory Analysis

Sensory evaluation of cheese spread (texture, color, spreadability, flavor and overall acceptability) was executed according to the method of sensory analysis (Lawless and Heymann, 2010). The sensory analysis, semi-trained panelists were first selected by performing a training session to familiarize the sensory panelists with terminologies, and sensory parameters. Fresh cream cheese spread samples were prepared for evaluation and enclosed in an airtight container. The sample containers were number coded to prevent the biasedness of the panelists. Mineral water was given to each panelist to keep their mouth feel neutral after tasting the sample. The scores from each panelist for every parameter were recorded. These scores were later used to carry out statistical analysis.

2.6. Statistical Analysis

The results acquired by completing the analysis mentioned above were subjected to a two-way factorial with completely randomized design to check the level of significance by the methods described by Montgomery (2017).

3. RESULTS

3.1. Proximate Analysis

Moisture content

According to analysis of variance (ANOVA) the moisture content of cheese spread, treatment was highly significant ($P \leq 0.01$) and their interaction non-significant. The maximum moisture content was 54.81±0.54 of treatment T_0 while the minimum was 51.82±0.26 of treatment T_4. The Table **2** indicates the means value of moisture % in processed cheese spread supplement with ripened cheddar cheese.

Fat content

The fat content of cheese spread, treatments were highly significant (P ≤ 0.01) and their interaction was non-significant. The Table **2** indicates the means value of fat % in processed cheese spread supplement with ripened cheddar cheese, as the mean value T_0 contains the lowest amount of fat 26.12±0.10 and T_4 contains the highest amount of fat 27.32±0.090.

Ash content

According to ANOVA statistical analysis the variability in ash content of cheese spread, treatment were highly significant (P ≤ 0.01) and their interaction was non-significant. The Table **2** indicates the means value of ash % in processed cheese spread supplement with ripened cheddar cheese, as the mean value T_0 contains the lowest amount of ash 1.18±0.017 and T_4 contains the highest amount of ash 1.30±0.015.

Crude protein

According to the Table **2** indicates the variability in protein content of processed cheese spread as the mean value T_0 contains the lowest amount of protein 8.12±0.09 and T_4 contains the highest amount of protein 10.20±0.11, treatment was highly significant (P ≤ 0.01) and their interaction was non-significant. The crude protein quantity elevates as the amount of ripened cheddar cheese increase.

Titratable acidity

The effect of storage on the acidity was significant (P≥0.05), and the interaction of treatment and storage is significant (P≥0.05) but the effect of the treatment highly significant (P ≤ 0.01). The maximum acidity was 0.63±0.015 of treatment T_0 while the minimum was 0.62±0.012 of treatment T_4 as mentioned in Table **2**.

pH

The variability in pH of cheese spread, treatments and storage was highly significant (P ≤ 0.01) and their interaction significant (P ≤ 0.05). According to the mean values shown in Table **2**, T_0 contains the lowest of pH *i.e.*, 5.49±0.01 and T_4 contains the highest amount of pH *i.e.*, 5.51±0.02. The effect of treatment and storage on the acidity was highly significant (P ≤ 0.01), and the effect of the interaction non-significant (P≥0.05).

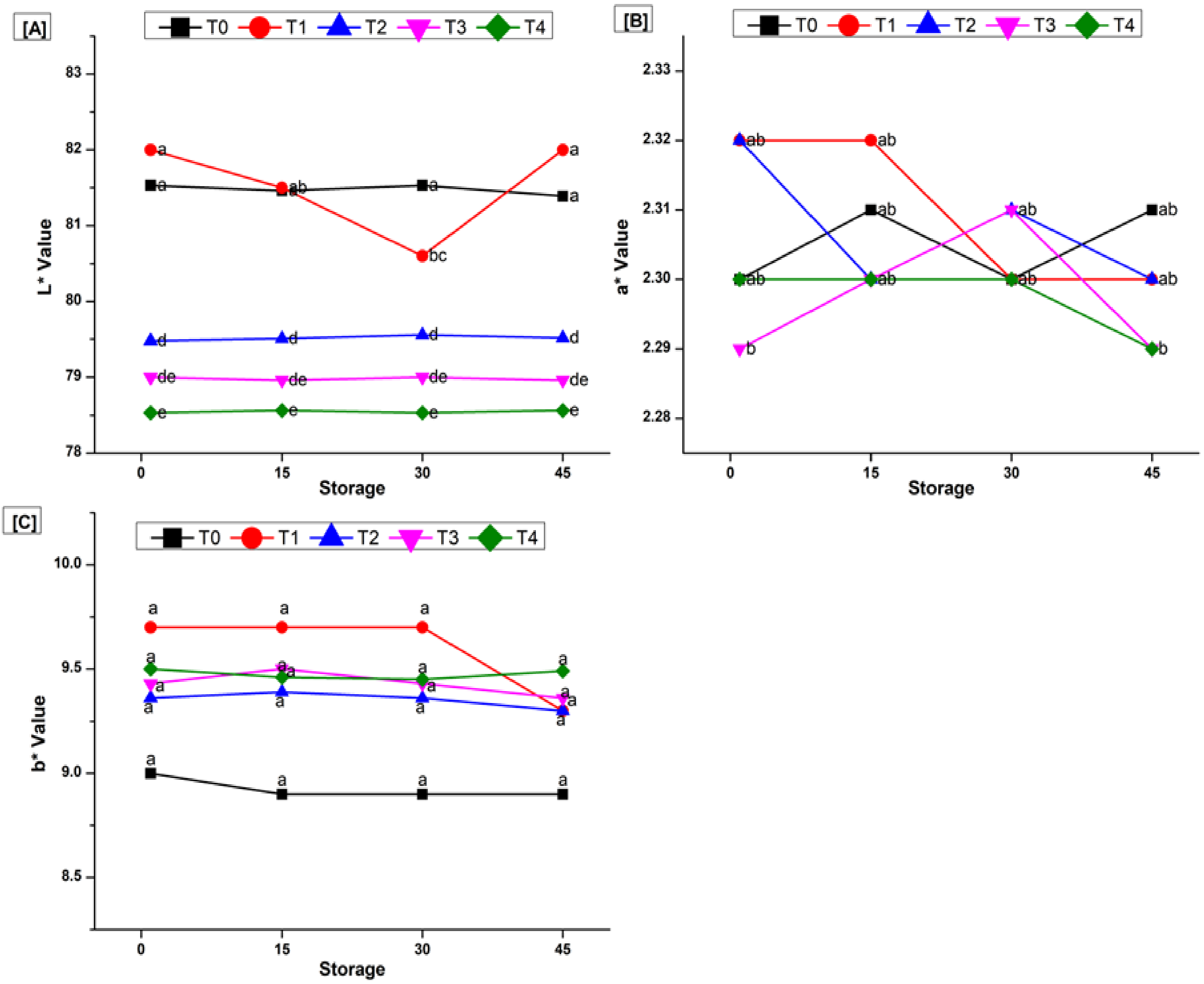

Figure 2. L*a*b* color value interaction with storage of processed cheese spread

3.2. Color Analysis

L value*

The analysis of the variance of the L value, the treatment had a significant effect on the L value of the samples, whereas, storage and their interaction effect is non-significant (P≥0.05). The lowest L value was found to be 78.53±0.32 in T_4 at 30th day of the storage; the highest L value was 81.53±0.05 in T_0 on the 30th day of storage time as Fig **2**.

a value*

The a* value for the prepared samples of cheese spread, the effect of treatments was non-significant (P≥0.05) whereas the storage intervals and interaction effect also had a non-significant (P≥0.05) effect on the a* value of samples. The minimum value was 2.30±0.01 in T_0 on the 0th day of storage time. Meanwhile, the maximum value was 2.32±0.01 in T_2 on the 0th day of storage interval. The data indicated that the a* value was towards greener hue (+).

b value*

The treatment had a significant (P ≤ 0.05) effect on the b* value of cheese spread samples. But the storage intervals and interaction effect of both treatment and storage time were non-significant (P≥0.05). The mean of the b* value for samples with the greatest value was 9.49±0.01 in T_4 on the 30th day of the storage time whereas the smallest value was 8.90±0.85 in T_0 on the 15th day of the storage time. It showed from the results that the b* value of samples was decreased towards bluish hue (+).

Table 2. Effect of Storage Time on Physiochemical and Emulsion Stability of Processed Cheese Spread Supplemented with Ripened Cheddar Cheese at Room Temperature

Parameter	Treatments	Storage (Days)				Mean
		01	15	30	45	
Moisture	T_0	55.00±0.60^{a}	54.53±0.46^{ab}	54.90±0.36^{ab}	54.83±0.30^{ab}	54.81±0.54^{A}
	T_1	54.45±0.44^{ab}	54.50±0.26^{abcd}	54.61±0.57^{ab}	54.50±0.51^{ab}	54.22±0.39^{B}
	T_2	53.45±0.50^{cde}	53.34±0.35^{e}	53.43±0.20^{de}	54.43±0.25^{de}	53.41±0.30^{C}
	T_3	52.46±0.38^{f}	52.50±0.45^{f}	52.45±0.25^{f}	53.40±0.26^{de}	52.70±0.51^{D}
	T_4	51.83±0.18^{f}	51.80±0.33^{f}	51.83±0.45^{f}	51.87±0.15^{f}	51.82±0.26^{E}
Fat	T_0	26.12±0.10^{j}	26.10±0.12^{j}	26.16±0.20^{ij}	26.11±0.17^{j}	26.11±0.13^{E}
	T_1	26.50±0.15^{hij}	26.48±0.17^{ghij}	26.49±0.17^{hij}	26.48±0.30^{efgh}	26.29±0.17^{D}
	T_2	26.69±0.2^{cde}	26.67±0.12^{def}	26.68±0.28^{cde}	26.65±0.19^{efg}	26.67±0.18^{C}
	T_3	26.95±0.05^{bc}	26.92±0.09^{bcd}	26.93±0.07^{bcd}	26.97±0.03^{b}	26.94±0.059^{B}
	T_4	27.28 ±0.26^{a}	27.32 ±0.09^{a}	27.29±0.10^{a}	27.27±0.12^{a}	27.29±0.1^{A}
Ash	T_0	1.18±0.02^{hij}	1.19±0.03^{ij}	1.17±0.02^{j}	1.18±0.02^{ij}	1.18±0.017^{E}
	T_1	1.22±0.02^{efgh}	1.22±0.01^{efgh}	1.23±0.01^{ghi}	1.22±0.01^{efgh}	1.22±0.013^{D}
	T_2	1.24±0.01^{efg}	1.23±0.01^{efg}	1.24±0.02^{de}	1.25±0.01^{def}	1.24±0.013^{C}
	T_3	1.27±0.01^{cd}	1.27±0.01^{bc}	1.26±0.02^{bc}	1.27±0.01^{cd}	1.27±0.012^{B}
	T_4	1.30±0.01^{ab}	1.29±0.02^{a}	1.30±0.01^{ab}	1.30±0.02^{ab}	1.30±0.015^{A}
	T_4	10.19±0.16^{a}	10.21±0.10^{a}	10.24±0.08^{a}	10.19±0.16^{a}	10.20±0.11^{A}
Crude Protein	T_0	8.11±0.12^{e}	8.12±0.10^{e}	8.13±0.08^{e}	8.12±0.3^{e}	8.12±0.09^{E}
	T_1	8.58±0.06^{d}	8.57±0.07^{d}	8.59±0.12^{d}	8.58±0.10^{d}	8.51±0.08^{D}
	T_2	9.19±0.12^{c}	9.21±0.08^{c}	9.18±0.06^{c}	9.20±0.09^{c}	9.19±0.10^{C}
	T_3	9.68±0.14^{b}	9.66±0.07^{b}	9.67±0.09^{b}	9.68±0.04^{b}	9.67±0.08^{B}
	T_3	10.19±0.16^{a}	10.21±0.10^{a}	10.24±0.08^{a}	10.19±0.16^{a}	10.20±0.11^{A}
	T_4	0.62±0.02^{ab}	0.62±0.01^{ab}	0.63±0.01^{ab}	0.63±0.01^{ab}	0.62±0.012^{A}
pH	T_0	5.50±0.01^{defg}	5.49±0.02^{ab}	5.49±0.01^{g}	5.48±0.01^{g}	5.49±0.02^{D}
	T_1	5.49±0.01^{abc}	5.50±0.01^{abcdefg}	5.49±0.02^{bcdf}	5.48±0.02^{g}	5.49±0.01^{CD}
	T_2	5.53±0.01^{a}	5.51±0.02^{ab}	5.52±0.01^{ab}	5.51±0.01^{defg}	5.51±0.015^{AB}
	T_3	5.51±0.02^{abc}	5.50±0.01^{abcd}	5.49±0.01^{abc}	5.50±0.01^{eg}	5.50±0.015^{BC}
	T_4	5.52±0.01^{ab}	5.51±0.02^{abc}	5.52±0.01^{a}	5.50±0.01^{abcd}	5.51±0.011^{A}

Means that don't share a letter in the column or row are significantly different from each other (P ≤ 0.05).

T_0 Controlled sample containing of 0% Ripened Cheddar Cheese
T_1 Sample containing of 5% Ripened Cheddar Cheese
T_2 Sample containing of 10% Ripened Cheddar Cheese
T_3 Sample containing of 15% Ripened Cheddar Cheese
T_4 Sample containing of 20% Ripened Cheddar Cheese

3.3. Texture Profile Analysis

Firmness

The analysis of variance indicated that the effect of treatment on the firmness was highly significant (P≤0.01) and storage time influence was non-significant (P≥0.05). However, the interaction effect of both treatment and storage interval showed a non-significant effect (P≥0.05) on the firmness of the samples. The highest mean value for firmness was 1.113±0.005 in T_4 on the 45th day of the storage, the lowest mean value for firmness was 1.08±0.01 in T_1 on the 45th day of storage.

3.4. Sensory Evaluation

Adhesiveness

The mean square shows the adhesiveness of the processed cheese spread and expressed that the treatments had a highly significant (P≤0.05) effect on the adhesiveness of the samples but the effect of storage was non-significant (P≥0.05). The interaction effect of both treatment and storage was also non-significant (P≥0.05).

Cohesiveness

The addition of ripened cheddar cheese resulted, the treatment had a non-significant (P≥0.05) effect on the cohesiveness score of the samples and, also the storage time had a non-significant effect on the cohesiveness score (P≥0.05). Similarly, the interaction effect of both treatment and storage was also non-significant (P≥0.05). However, the highest value was 6.83±0.057 of T_2 on the storage meanwhile the lowest value was 6.58±0.051 in T_0 on the storage.

Spreadability

The treatment had a highly significant (P≤0.01) effect on the spreadability score of cheese spread but storage intervals did not influence the spreadability score of samples and the effect was non-significant (P≥0.05). It meant that an increase in the quantity of ripened cheddar cheese resulted in lowering the spreadability.

Overall acceptability

The effect of treatment on the overall acceptability was highly significant (P≤0.01) and storage time influence was non-significant (P≥0.05). However, the interaction effect of both treatment and storage interval showed a non-significant effect (P≥0.05) on the overall acceptability of the samples.

Flavor

The treatment has highly significant effect (P≤0.01) on the buttery flavor whereas the storage interval also had non-significant effect (P≥0.05). The highest value was 7.83±0.57 in T_3 at the 0th day of storage whereas the lowest value was 6.58±0.51 in T_0 on the 0th day of storage.

4. DISCUSSION

4.1. Proximate Analysis

The moisture content was decreased as ripened cheddar cheese quantity increased in cheese spread because the ripened cheddar cheese had less moisture content compared to fresh cream cheese. The moisture content in processed cheese spread and their impact on quality were showed consistent with the previous studies by (MN and MM, 2009). The amount of fat in the sample did not affect on sourness, while the amount of fat in the sample affected on salty. It was discovered that lowering fat levels resulted in a loss of ‘rounded' odors, the butter flavor, which was milder in samples with lower fat levels (Wendin *et al*., 2000).

Cream cheese's lubricating qualities may be influenced by the presence of fat, in a free and intact globular state (Ningtyas *et al*., 2017). In general, the trend of the data shows that the protein content increased with an elevation in the amount of ripened cheddar cheese whereas the storage showed no noticeable influence on the protein of the samples. The protein content of cheese spread and their treatment were found consistent with previous study of (Kebary *et al*., 2018). Ash content of processed cheese spread and their treatment were found consistent with previous studies (Tawfek, 2018). Ash contents of processed cheese spread was increased as the %age ripened cheddar cheese was added in cheese spread. The treatments had a visible effect on the ash content of the samples, due to the addition of ripened cheddar cheese which might have played a vital role in the increase in the mineral content (Singh and Chandra, 2017). In general, the ash content in dairy products is considered to be the root of various vitamins and minerals present in them (Jackson and Lee, 1992).

When acid formation started as the activity of lactic acid bacteria, the titratable acidity increased meanwhile the pH of the samples started to decrease. The determination of the quality of the cheese spread, acidity plays role in the texture and sensory properties. It is seen that moisture and acidity of the cheese spreads were not significantly influenced by the addition of whey protein concentrate (Pinto *et al*., 2007). The increase in acidity can be attributed to the acid formation by lactic acid bacteria during the storage of the samples (Banks and Williams, 2004). As the decrease in pH changes the texture becomes grainy and firm and an increase in pH causes it to become a moist, soft, and elastic texture (Lee and Klostermeyer, 2001). Lowering the pH of the cheese to 4.7 from 5.3 caused the protein matrix to str*etc*h. When it reduced from 5.3 to 5.0, the rate of cheese flow increased. At pH 4.7, the final amount of cheese flow was also reduced. Finally, decreasing the pH of cheddar cheese modifies protein interactions, determines cheese functioning. Protein acid precipitation reverses the opposing effect of greater calcium solubilization and lowered calcium concentration of cheese at pH lower than 5, and protein-to-protein interactions rise (Pastorino *et al*., 2003).

For the quantification of the color, the CIE color scale was used in which three values were noted generally known as L*, a*, b* values (Giri *et al*., 2018). During storage at high temperatures, cheese spread suffers from discoloration, hardness, and emulsion destabilization.

4.2. Texture Profile Analysis

Firmness is the feeling of hardness when consumed. Various molecular and compositional factors take part in this property (Kapoor *et al*., 2004). Ripened cheddar cheese had low moisture than fresh cheese and a harder texture, so firmness increased as it was added. In processed cheese spread, the firmness increased as the %age of ripened cheddar cheese increased as in T_4.

4.3. Sensory Evaluation

Adhesiveness is described to imitate as the stickiness of the sample in the mouth throughout mastication (from slippery to sticky). This characteristic of the food product is of immense importance not only for consumer acceptance but also for industrial processing as well (Drake *et al*., 1999). The fat content has an effect on adhesiveness. The structure of full-fat cheese altered as the temperature climbed, and the fat softened, increasing the adhesiveness (Zheng *et al*., 2016). Adhesiveness increases as the percentage of ripened cheddar cheese increased in treatments. During the development of the cream cheese and especially cheese spread, this property is of utmost importance not only for consumer acceptance but also for the processing line of cheese spread as well.

Cohesiveness is defined as the ability of the particles to cling to particles identical, usually exist in the form of a lump. The quantity to represent the toughness of the internal linkages that make up the product's structure is cohesiveness. In general, the mean values were not increases much with treatments and the ripened cheddar cheese. The variety of texture stabilizing substances applied to spreadable processed cheese seems to increase cohesiveness values (Dabour and Ali, 2018).

The color of cheese spread is of great importance as it helps in determining the quality and type of cheese spread. It plays an important role in consumer acceptance as well. In general, the trend depicted by the table was that the color of samples was moving towards a yellowish hue with an increase of the ripened cheddar cheese whereas the storage time did not impact the color noticeably.

Spreadability was defined as the force required obtaining the maximum penetration depth of 2 mm (Brighenti *et al*., 2008). For the development of a smooth, consistent, and spreadable cheese spread is of top priority for any food manufacturing company. The higher the force required, the lower the spreading ability and lower the force required, the higher the spreadability (Salek *et al*., 2015).The characteristic flavor developed by the aromatic bacteria which produces diacetyl flavor (Rincon-Delgadillo *et al*., 2012). The higher the concentration of diacetyl flavor, the higher will be the buttery flavor score. Higher the lactic acid (produced by the fermentation), the greater the acidic flavor. The mild acidic flavor is the characteristic of cheese spread but too much acidic flavor results in poor consumer acceptance (Fox *et al*., 1998).

Overall acceptability of processed cheese spread increased as the amount of ripened cheddar cheese increased in treatment up to 15%, the texture, flavor, taste and mouth-feel improved by adding cheddar cheese. Overall acceptability doesn't affect by the storage.

5. CONCLUSION

The role of ripened cheddar cheese and storage intervals on the quality parameters of processed cheese spread was investigated, the effects of ripened cheddar cheese on the processed cheese spread, by analyzing its physicochemical, emulsion properties and sensory evaluation using sensory analysis techniques. In the physicochemical analysis, protein content was significantly affected (increased) with increasing the concentration of ripened cheddar cheese. However, the pH, acidity, and moisture content of the samples were affected noticeably with storage time whereas fat content and ash content were also affected observably. The L*, a*, b* value of the colorimeter was affected significantly by the treatment as well as storage time. The attributes in the sensory analysis were influenced greatly by the ripened cheddar cheese. Texture profile analysis (TPA) of samples showed similar results. In general, T_3 and T_4 containing 15% and 20% of ripened cheddar cheese showed better results. However, to better understand the interaction of ripened cheddar cheese and fat, the rheological and microstructure of processed cheese spread should be investigated further.

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7. CONFLICTS OF INTERESTS

Authors are required to disclose financial or non-financial interests that are directly or indirectly related to the work submitted for publication.

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