Yield and Sensory Qualities of Cow and Soy Milk Cheese as Influenced by Heat Treatment Duration and Coagulant Types

Abstract

One of the problems encountered by the dairy industry is the loss in output (yield) during cheese processing. This study evaluates the yield of cheese from soy and cow milk as impacted by heat treatment duration and coagulant type. The 3^2 factorial design was employed to determine the nine samples that were produced. The milk (soy milk and cow milk) were pasteurized at 65°C for 10 minutes and subjected to thermal treatment for another 15, 20 and 25 minutes respectively. The initial qualities of the raw cow and soy milk were determined which served as the control. Coagulants such as lime juice, tamarind pulp and moringa seed paste were added to each of the samples which was then cooled for 30 minutes before the whey was pressed out. The yield rate of the cheeses were determined by standard procedures and statistically analyzed. The results showed that cow and soy milk cheese samples produced with moringa coagulant for 25 minutes respectively had the highest total percentage yield and a good general acceptability. However, the sensory evaluation carried out on the cheese samples produced from tangerine coagulant at 20 minutes were the most acceptable to the panelists but possessed lower total percentage yield. Hence, moringa coagulant is recommended for high cheese yield and good sensory quality.

Keywords: cow-milk cheese, soy-milk cheese, cheese yield, coagulants, heat treatment.

1.0 Introduction

Cheese is a nutritious food product that is mostly produced from milk of cow (animal source) and soybean (plant source). It is valued for its profitability, portability, shelf life and high mineral content (Paul *et al*., 2021). Generally, cheese stability is within three to five days when produced, it has longer shelf life than milk, though this depends on the type of cheese (Lamont *et al.*, 2017). During the production of cheese, milk is coagulated and acidified by adding rennet which causes coagulation and the coagulated milk solids are separated from the whey and pressed into final form using molds (Orhevba *et al*., 2019). Milk could also be curdled by adding lemon juice and vinegar while cheeses can also be acidified by other means such as adding bacteria which aid in turning the milk sugars to lactic acid, the curdling process is completed by adding rennet (Paul *et al*., 2020).

Selected biological coagulants that are high in nutrients which could add to cheese nutrients includes lime juice, moringa kernel cake and tamarind pulp. The moringa oleifera plant has seeds that are highly nutritious and functional (Koc *et al.*, 2014; Olugbuyiro and Oseh, 2011). These seeds are versatile and can be applied in medicinal and herbal remedies, as well as nutritional supplements for the food industry and other agricultural purposes (Sunmola *et al.,* 20222). The benefits of lime in skin and health care include skin care, eye care, weight loss, improved digestion, relieve from constipation and treatment of piles, peptic ulcer, scurvy, respiratory and urinary disorders (Ratti and Kudra, 2006). Tamarind fruit contains functional compounds, minerals, vitamins and dietary fiber. It is highly rich in vital vitamins such as thiamin with 36% daily requirement level in the body, vitamin-C, vitamin-A, riboflavin, folic acid and niacin. These vitamins function as antioxidant and also as metabolism enzymes in the body system (Arise *et al*., 2014). However, there are plant sources of milk which their consumption had been for centuries in various cultures and serve as substitutes for dairy milk. They include soy milk, almond milk, rice milk and coconut milk. Plant milk are consumed for several reasons such as lactose intolerance, milk allergy, vegetarianism, religious reasons and simple taste preference (Raikos, 2010). Moreover, animal source of milk contains lactose which could be indigestible for adult, thus there is need for milk to be converted to other milk products such as yoghurt and cheese which are products of milk fermentation (Damunupola *et al*., 2014; Dehghannya *et al*., 2018).

Heat processing is a very crucial method of extending the storage life of food products. Hence, enhancing food nutrients to be available to consumers. However, heat processing has its own side effect on nutrients which lead to thermal degradation of nutrients during thermal processing (Paul *et al*., 2019; Sunmola *et al*., 2021). Though, thermal processing increases the availability and shelf life of food products, such food product may have a lower nutrient content when compared to the fresh sample. Thus, the challenge of the processing industry is on how to minimize loss of vital nutrients during thermal processing while ensuring adequate storage life of the food product (Avosuahi *et al*., 2023). Success has been recorded in the application of reagents such as $CaCl_2$ in the coagulation of milk to cheese but it is recommended and more efficient to use biological coagulants for cheese production. These biological coagulants have no adverse effect on human but rather serves as fortifications and additives. These coagulants are readily available and highly effective in milk coagulation (Zolelw and Victoria, 2020). The objective of this study is to determine the yield of cow milk and soy milk cheese as influenced by heat treatment duration and coagulant types. Three experimental batches were realized for each of the samples (raw milk, soymilk and eighteen different samples) making a total of twenty experimental setups. Data obtained were subjected to Analysis of Variance (ANOVA) and Duncan multiple range test to separate the means.

Soybeans are rich in nutritive contents such as protein, fiber, calcium and magnesium. They are also low in saturated fatty acids but rich in the unsaturated while soy milk is a plant milk produced through the process of soaking the soybeans in water for 45 minutes, milled and filtered (Sunmola *et al*., 2022). Soy milk is a stable emulsion of oil, water and protein. It is a complete protein and has about the same amount of protein as cow's milk; it can replace animal protein and other sources of dietary fiber, vitamins and minerals (Zanhi and Jideani, 2012). Soy products contain basic disaccharide such as sucrose which breaks down into glucose and fructose. Soy does not contain galactose (a product of lactose breakdown). Therefore, infant formulas that are soy-based can safely replace breast milk in children with galactosemia. Soymilk also does not contain which makes it a better alternative for those who are lactose-intolerant (Paul et al., 2020).

The use of lime includes its importance in the production chemicals such as cyanide acid, sodium alkalis, calcium chlorite, petrochemicals, propylene, glycol glycerine and many others. More use of lime is employed in the production process of precipitated calcium carbonate, a substance used in the production of paper and for purification of water (Ratti and Kudra, 2006). Tamarind (*tamanidus indica)* is a tropical fruit with multipurpose utilities such as seasoning, its fruits and seeds are also been processed for non-food uses. The whole tamarind seed contained 13-20% protein, the seed coat had 20% fibre and 20% tannins. Tamarind has been recommended as stabilizers in ice cream production, mayonnaise and cheese making. Also, as an ingredient in a number of pharmaceutical products (Sunmola *et al*., 2021). Fresh moringa seeds are usually quite soft and yield with strong pressure. If the moringa seeds are to be used for oil extraction, the seeds are harvested and immediately processed. The fresh soft seeds are broken into pieces and heated with water, and they are pressed for oil. Moringa oleifera seeds contained as high as 30 – 42% protein while its cake contained active cationic polyelectrolyte (Arise *et al*., 2014). Lime fruit, tamarind fruit and moringa seed are shown in Plate 1.

(a) (b) (c)

Plate 1: (a) Lime fruit (b) Tamarind Fruit (c) Moringa Seed

Source: Sunmola *et al*., 2022

2.0 Materials and Methods

Material used in the study are discussed as follows:

The soy-beans and the cow milk samples used for this study were obtained from Sabo market, Southern-Kaduna, Nigeria. The ingredients used (moringa seed, lime and tamarind fruit) were also obtained from the market.

2.1 Equipment and Reagents

The equipment used for the experiment includes oven, electric blender, digital weighing balance, retort stand, funnel, test tubes, conical flask, pipette, beaker spatula, crucible, desicators, measuring cylinder, soxhlet flask, filter paper, petri dishes, blender, thermometer, cotton wool, aluminum foil, stirrer, stove, pot, cheese knife, bowls, cheese cloth, mortar and pestle.

2.2 Preparation of coagulants

The three coagulants used were prepared through different processing methods which are as follow:

(a) Moringa oleifera seeds

Moringa oleifera seeds were firstly dehulled and weighed before been put in a pot to be toasted for 3 minutes after which the seeds were milled using electric blender. The oil was then extracted through the use of steamed water to manually press out the oil. The seed paste obtained was used as a coagulant. Fig 1 shows the flow process involved in seed paste production.

(b) Lime Juice extraction

The fresh limes were sorted, washed, cut and squeezed out to extract the lime juice. The lime juice was then used as a coagulant in the production of cheese samples from cow and soy milk. 75 ml of the lime juice was used for the cheese production.

(c) Tamarind Juice pulp

The tamarind seeds were cleaned, sorted, washed and soaked in hot water for about four (4) hours and sifted to obtain the tamarind pulp which was used as a coagulant in the production of cheese from cow and soy milk. 75 ml of the tamarind pulp was used for cheese production.

2.3 Production of soy milk

The soy beans were sorted, washed thoroughly and soaked in hot water for about four (4) hours, before it was wet milled and the milk filtered out. The milk obtained was cooked to obtain soy milk as shown in Fig 1.

Soybean seeds (2kg)
↓
Sorting
↓
Weighing
↓
Steeping (6hours)
↓
Dehulling
↓
Cleaning
↓
Washing
↓
Milling
↓
Filtration → Residue
↓
Soymilk

Fig 1: Soy Milk Production

Source: (Paul *et al*., 2020)

2.4 Production of cheese

The raw cow milk was pasteurized at 65°C for 10 minutes before the coagulants were added to the respective samples and subjected to another 15, 20 and 25 minutes heat treatment to form curds as designated on the experimental design. The heated samples are then cooled for 30 minutes before the whey was separated using muslin cloth. The cheese samples were pressed and cut into desired sizes, packed and stored. The process for the production of the cow milk cheese is shown in Figure 2.

Raw Milk
↓
Pasteurization
↓
Cooling
↓
Inoculation
↓
Mixing
↓
Incubation
↓
Cutting
↓
Heating
↓
Stir and draining
↓
Cutting
↓
Mixing
↓
Filling
↓
Pressing
↓
Packing
↓
Storage/ Ripening

Fig 2: Production of cheese from cow milk

Source: (Paul *et al*., 2020)

2.5 Experimental Design

The 3^2 factorial design was used as in the study to determine the number of runs. Wherewith, we have Nine (9) runs for the cow milk cheese and Nine (9) run for soy milk cheese. Total of Eighteen samples were used in the study. The experimental design for the study is shown in Table 1 while Table 2 and 3 showed the codes for the cheese samples produced from cow and soy milk. The volume of milk used for both milk samples was 1000ml per runs.

Table 1: Experimental Design Table

Experimental Design			
Parameters	High	Middle	Low
Heat Treatment	1	0	-1
Duration	15	20	25
Coagulants	Lime (A, D)	Tamarind pulp (B, E)	Moringa seed Paste (C, F)

Table 2: Codes for cheese samples produced from cow milk

Runs	Codes	Meaning
1	A_{15}	Lime coagulated cheese with heat treatment duration of 15 minutes
2	A_{20}	Lime coagulated cheese with heat treatment duration of 20 minutes
3	A_{25}	Lime coagulated cheese with heat treatment duration of 25 minutes
4	B_{15}	Tamarind pulp coagulated cheese with heat treatment duration of 15 minutes
5	B_{20}	Tamarind pulp coagulated cheese with heat treatment duration of 20 minutes
6	B_{25}	Tamarind pulp coagulated cheese with heat treatment duration of 25 minutes
7	C_{15}	Moringa seed paste coagulated cheese with heat treatment duration of 15 minutes
8	C_{20}	Moringa seed paste coagulated cheese with heat treatment duration of 20 minutes
9	C_{25}	Moringa seed paste coagulated cheese with heat treatment duration of 25 minutes

3.0 Yield Analysis of Cow and Soy Milk Samples

The yield was expressed in percentage (%). The weight of cheese obtained from 1000 ml of milk divided by the weight of 1000ml of the milk. The total yield percentage was calculated as:

$$\text{Total yield percentage} = \frac{\text{Mass of cheese}}{\text{Mass of 1000ml of milk}} \times 100 \qquad 1$$

Sensory qualities such as flavour, texture and taste were evaluated using a ten point hedonic scale. Panelists featured were Food processing students whom are organoleptically familiar with both cow milk and soy cheese. The hedonic scale was ranked as follows: 10-8 scores: like extremely to very much, 7-5 scores: moderately to slightly like, 4-2 scores: neither like nor dislike to dislike slightly to dislike moderately and 1-0 scores: dislike very much to dislike extremely. A total of 20 panelists were engaged to evaluate the sensory attributes of the cheese samples.

Table 3: Codes for cheese samples produced from Soy milk

Runs	Codes	Meaning
1	D_{15}	Lime coagulated Soy cheese with heat treatment duration of 15 minutes
2	D_{20}	Lime coagulated Soy cheese with heat treatment duration of 20 minutes
3	D_{25}	Lime coagulated Soy cheese with heat treatment duration of 25 minutes
4	E_{15}	Tamarind pulp coagulated Soy cheese with heat treatment duration of 15 minutes
5	E_{20}	Tamarind pulp coagulated Soy cheese with heat treatment duration of 20 minutes
6	E_{25}	Tamarind pulp coagulated Soy cheese with heat treatment duration of 25 minutes
7	F_{15}	Moringa seed paste coagulated Soy cheese with heat treatment duration of 15 minutes
8	F_{20}	Moringa seed paste coagulated Soy cheese with heat treatment duration of 20 minutes
9	F_{25}	Moringa seed paste coagulated Soy cheese with heat treatment duration of 25 minutes

The mass of milk, mass of curds, volume of milk, volume of whey, yield, percentage yield of curds and percentage yield of whey of cow milk cheese samples are shown in Table 4.

Table 4: Mass, Volume and Yield of Cow milk Cheese Samples

Sample	Vol. of Milk (ml)	Mass Of Milk (g)	Mass Of Curds (g)	Volume Of Whey (ml)	Yield= $\frac{mass\ of\ curd}{mass\ of\ milk}$	%Yield curds	%Yield whey
A_{15}	1000	1101.7	117.4	450	0.107	10.7	45.0
A_{20}	1000	1101.7	126.1	370	0.114	11.4	37.0
A_{25}	1000	1101.7	133.2	360	0.121	12.1	36.0
B_{15}	1000	1101.7	133.3	530	0.121	12.1	53.0
B_{20}	1000	1101.7	134.0	370	0.122	12.2	37.0
B_{25}	1000	1101.7	142.5	330	0.129	12.9	33.0
C_{15}	1000	1101.7	183.5	410	0.167	16.9	41.0
C_{20}	1000	1101.7	197.9	330	0.180	18.0	33.0
C_{25}	1000	1101.7	204.2	140	0.185	18.5	14.0

A= Lime Coagulated Cow Cheese — 15 = 15 minutes cooking Time
B= Tamarind Coagulated Cow Cheese — 20 = 20 minutes cooking Time

C= Moringa Coagulated Cow Cheese 25 = 25 minutes cooking Time

The cow milk cheese samples had the same volume (1000ml) and mass (1101.7g). The mass of curds for the lime, tamarind and moringa coagulated cow milk cheese all increased with increase in heating duration while the volume of whey for the samples decreased with increase in heating duration due to evaporation of the whey. The percentage yield of curds increased with heating duration while the percentage yield of whey decreased with heating duration. The mass of milk, mass of curds, volume of milk, volume of whey, yield, percentage yield of curds and percentage yield of whey of soy milk cheese samples are shown in Table 5.

Table 5: Mass, Volume and Yield of Soy Cheese Samples

Sample	Vol. of Milk (ml)	Mass Of Milk (g)	Mass Of Curds (g)	Volume Of Whey (ml)	Yield= $\frac{mass\ of\ curd}{mass\ of\ milk}$	%Yield curds	%Yield whey
D_{15}	1000	1009	157.3	500	0.158	15.8	50.0
D_{20}	1000	1009	159.6	290	0.187	18.7	29.0
D_{25}	1000	1009	188.8	180	0.156	15.6	18.0
E_{15}	1000	1009	185.6	520	0.134	13.4	41.0
E_{20}	1000	1009	187.3	410	0.186	18.6	52.0
E_{25}	1000	1009	206.9	400	0.205	20.5	40.0
F_{15}	1000	1009	247.3	470	0.246	24.6	47.0
F_{20}	1000	1009	247.6	440	0.245	24.5	44.0
F_{25}	1000	1009	248.7	420	0.245	24.5	42.0

D= Lime Coagulated Soy Cheese 15 = 15 minutes cooking Time
E= Tamarind Coagulated Soy Cheese 20 = 20 minutes cooking Time
F= Moringa Coagulated Soy Cheese 25 = 25 minutes cooking Time

The soy milk cheese samples are of the same volume (1000ml) and mass (1101.7g). The mass of curds for the lime, tamarind and moringa coagulated cow milk cheese increased with increase in heating duration. The volume of whey for lime and moringa samples decreased. The percentage yield of curds for tamarind and moringa increased while the percentage yield of whey of lime and moringa decreased with heating duration. The influence of heat treatment duration and coagulant types on the total yield of cheese from cow and soy milk is shown in Table 6 and 7.

Table 6: The Influence of Heat Treatment Duration (HTD) and Coagulant Types on the Total Yield of Cheese from Cow Milk

	Total Percentage Yield (%) as influenced by Coagulants at different HTD		
Sample	**15 mins**	**20 mins**	**25 mins**
A	10.5	11.4	12.1
B	12.1	12.2	12.9
C	16.9	18.0	18.5

A= Lime coagulant cow milk cheese, B= Tamarind coagulant cow milk cheese, C= Moringa coagulant cow milk cheese

From Table 6, it was observed that the cow milk cheese total yield ranged between 10.5 and 18.5%. This showed that heat treatment duration and the coagulants types affects the yield of cheese curds. At heat treatment duration (HTD) of 15, 20 and 25 minutes, sample C had 16.9, 18.0 and 18.5% respectively, with C_{25} having the highest total percentage yield (18.5%). More so, the result showed that the increase in duration of heating also affected the yield of A and B as the yields increased with HTD.

Table 7: The Influence of Heat Treatment Duration (HTD) and Coagulant Types on the Total Yield of Cheese from Soy milk.

	Total Percentage Yield (%) as influenced by Coagulants at different HTD		
Sample	**15 mins**	**20 mins**	**25 mins**
D	15.8	18.7	15.6
E	13.4	18.6	20.5
F	24.6	24.5	24.5

D=Lime coagulant soy milk cheese, E= Tamarind coagulant soy milk cheese, F= Moringa coagulant soy milk cheese

The result of the total percentage yield of soy milk cheese (Table 7) showed that the heat treatment duration affects the total yield of cheese produced. Sample F had 24.6, 24.5, and 24.5% at 15, 20 and 25 minutes heat treatment durations with F_{15} having 24.6% which was the highest total yield obtained. Meanwhile, sample D yield also increased from 15 to 20 minutes but later decreased at 25 minutes. This may be due to the long time heat treatment and the sticking of the curds on the cooking vessel. However, sample E maintained a steady increase from 13.4% to 20.5%.

4.0 Sensory Evaluation of cow and soy milk cheese as influenced by different heat treatment durations and coagulant types.

The mean sensory evaluation of cow and soy milk cheese are shown in Table 8 and 9.

Table 8: Mean Sensory Evaluation of Cow Milk Cheese using different Heat Treatment Durations and Coagulants

Attributes	A_{15}	A_{20}	A_{25}	B_{15}	B_{20}	B_{25}	C_{15}	C_{20}	C_{25}
Texture	7.1 ± 0.5^{ab}	6.7 ± 0.6^{ab}	5.6 ± 0.9^{a}	5.9 ± 0.7^{a}	7.8 ± 0.4^{c}	7.3 ± 0.3^{a}	6.8 ± 0.5^{ab}	6.8 ± 0.3^{ab}	7.2 ± 0.5^{ab}
Flavour	6.4 ± 0.6^{abc}	5.6 ± 0.6^{ab}	5.1 ± 0.8^{a}	5.2 ± 0.7^{a}	7.1 ± 0.5^{bc}	7.6 ± 0.5^{c}	6.9 ± 0.5^{abc}	6.3 ± 0.5^{abc}	6.7 ± 0.5^{abc}
Colour	8.0 ± 0.3^{de}	7.3 ± 0.2^{bcd}	6.4 ± 0.5^{abc}	5.4 ± 0.8^{a}	8.2 ± 0.3^{e}	8.0 ± 0.3^{de}	7.0 ± 0.4^{bcde}	6.8 ± 0.4^{bcd}	5.7 ± 0.6^{ab}
Taste	6.2 ± 0.6^{ab}	5.3 ± 0.7^{a}	5.7 ± 0.7^{a}	5.5 ± 0.8^{a}	7.6 ± 0.6^{c}	$7.4\pm0.0.6^{c}$	6.7 ± 0.3^{ab}	7.3 ± 0.4^{ab}	7.4 ± 0.5^{ab}
Overall Acceptability	6.8 ± 0.5^{abc}	5.8 ± 0.6^{a}	5.6 ± 0.7^{abc}	5.7 ± 0.7^{ab}	8.0 ± 0.5^{d}	7.6 ± 0.4^{bc}	7.1 ± 0.2^{abc}	6.7 ± 0.4^{bc}	7.2 ± 0.5^{bc}

Values with the same superscript are not significantly different at 5% level of significance along the same column. Data are mean ± standard error of mean (SEM) of triplicate results. Mean ± SEM followed by the same letter on a column are not significantly different ($p<0.05$).

Table 8 showed the sensory evaluation of cow milk cheese as influenced by heat treatment, lime juice (A), tamarind extract (B) and moringa seed paste (C) on the samples texture, flavour, colour, taste and overall acceptability. The samples texture, flavour, colour, taste and overall acceptability were significantly different ($P>0.05$) with B_{20} as the most preferred followed by B_{25} and C_{25}.

Table 9: Influence of Heat Treatment and Coagulant types on the sensory qualities of Soy Cheese

Attributes	D_{15}	D_{20}	D_{25}	E_{15}	E_{20}	E_{25}	F_{15}	F_{20}	F_{25}
Texture	7.5 ± 0.4^{c}	6.6 ± 0.4^{ab}	5.7 ± 0.5^{ab}	6.7 ± 0.6^{ab}	6.0 ± 0.7^{ab}	5.3 ± 0.8^{a}	6.4 ± 0.6^{ab}	6.2 ± 0.7^{ab}	5.2 ± 0.8^{a}
Flavour	5.5 ± 0.8^{a}	5.4 ± 0.7^{a}	5.0 ± 0.8^{a}	7.0 ± 0.5^{a}	6.8 ± 0.4^{a}	6.0 ± 0.8^{a}	5.3 ± 0.7^{a}	5.4 ± 0.7^{a}	4.8 ± 0.9^{a}
Colour	7.6 ± 0.5^{c}	6.5 ± 0.4^{ab}	6.3 ± 0.7^{ab}	7.6 ± 0.5^{a}	6.3 ± 0.6^{ab}	6.6 ± 0.5^{ab}	6.2 ± 0.6^{ab}	6.2 ± 0.6^{ab}	5.5 ± 0.8^{a}
Taste	5.5 ± 0.7^{a}	5.3 ± 0.7^{a}	5.2 ± 0.8^{a}	6.8 ± 0.6^{a}	7.0 ± 0.5^{a}	6.4 ± 0.5^{a}	6.1 ± 0.7^{a}	6.5 ± 0.6^{a}	6.0 ± 0.7^{a}
Overall Acceptability	6.5 ± 0.6^{a}	6.3 ± 0.4^{a}	5.7 ± 0.5^{a}	7.0 ± 0.6^{a}	7.0 ± 0.5^{a}	6.6 ± 0.6^{a}	7.1 ± 0.5^{a}	7.3 ± 0.4^{a}	7.1 ± 0.4^{a}

Values with the same superscript are not significantly different at 5% level of significance along the same column. Data are mean ± standard error of mean (SEM) of triplicate results. Mean ± SEM followed by the same letter on a column are not significantly different ($p<0.05$).

Table 9 showed the sensory evaluation of soy milk cheese as influenced by heat treatment, lime juice (A), tamarind extract (B) and moringa seed paste (C) on the samples texture, flavour, colour, taste and overall acceptability. The samples texture, flavour, colour, taste and overall acceptability were significantly different (P>0.05) with E_{15} as the most preferred followed by D_{15} and E_{20}.

Conclusion

Cow and soy milk cheese samples produced with moringa coagulant for 25 minutes had the highest total percentage yield and a good general acceptability. However, the sensory evaluation carried out on the cow and soy milk cheese samples produced from tangerine coagulant at 20 minutes were the most acceptable to the panelists but possessed lower total percentage yield. Hence, moringa coagulant is recommended for high cheese yield and good sensory quality.

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