Proximate composition of packaged freeze-dried cheeses in storage

T. Paul[1*], B. A. Adejumo[2], N. R. Nwakuba[3], J. C. Ehiem[1]

*(1. Department of Agricultural and Bioresources Engineering, Michael Okpara University of Agriculture, Umudike, 440109, Abia State, Nigeria;
2. Department of Agricultural and Bioresources Engineering, Federal University of Technology, Minna, 920211, Niger State, Nigeria;
3. Department of Agricultural and Bioresources Engineering, Federal University of Technology, Owerri, 460114, Imo State, Nigeria.)*

Abstract: The proximate composition of packaged freeze-dried cow milk cheese and soy cheese in storage were investigated. Fresh cow milk cheese and soy milk cheese of 600 g each were prepared and cut into sizes of 3 × 3 cm dimension and a thickness of 0.3 cm. 100 g each of the fresh cheese samples was used to determine the initial properties while the remaining 500 g were open freeze-dried. The initial properties of the freeze-dried samples were determined using a portion of each of the samples. A randomized experimental block design was adopted. The freeze-dried samples were packaged in a sterile tightly covered glass jar, sterile tightly covered plastic container and a sterile polythene film while the unpackaged sample was used as the control sample. The samples were stored at 35 – 40°C and 90 - 95% relative humidity for three months. Samples were analyzed for their proximate qualities monthly during the storage period. Data obtained were analyzed statistically to determine the effect of the packaging materials and storage durations on the proximate composition of freeze-dried cheese samples. Result of the mineral composition for the fresh cow milk and soy cheese for moisture content (%), ash (%), protein (%), fat (%), and carbohydrate (%) were 54.02 ± 0.10, 6.40 ± 0.32, 20.34 ± 0.50, 18.11 ± 0.06, 4.25 ± 0.20 and 50.89 ± 0.12, 6.31 ± 0.31, 22.05 ± 0.02, 19.02 ± 0.58, and 4.06 ± 0.10, respectively; whereas the result for the freeze-dried cow milk and soy cheese before storage were 4.28 ± 0.10, 32.72 ± 0.12, 32.24 ± 0.28, 4.05 ± 0.98, 26.86 ± 0.90 and 4.19 ± 0.46, 30.98 ± 0.55, 34.84 ± 0.31, 4.30 ± 0.29, and 24.72 ± 0.01, respectively. The packaging material type used and storage duration have no significant effect on the proximate composition (moisture, carbohydrate, protein, ash, and fat) of the cow milk and soy milk cheeses after three months of storage. This indicates that all the packaging material types used can adequately retain the proximate composition of freeze-dried cheese. It is therefore concluded that freeze-drying increases some proximate composition (carbohydrate, protein, and ash) of cheeses and appropriate packaging enhance and extend the shelf life of cheeses.

Keywords: cheese, freeze-drying, proximate composition, packaging materials, storage duration, milk, Nigeria.

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1 Introduction

Cheese is considered to be an adequate source of valuable macronutrients (fat, protein, lactose), vitamins and micronutrients (minerals), making it a 'wholesome food'. It can serve as an excellent carrier product for extra nutrient, and if enriched or fortified it can satisfy the nutritional needs of the population. Non-dairy ingredients find a critical role in the synergy of the chemical constituents of dairy foods to enhance their proximate profile and at the same time influencing the cost of the resultant product (FAO/WHO, 2002). Nowadays, a shift is observable from the optimum in product quality to the optimum for the

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***Corresponding author: Paul, T.,** Lecturer, Department of Agricultural and Bioresources Engineering, Michael Okpara University of Agriculture, Umudike, Abia State, Nigeria. Tel: +234 703 924 0664. Email: ptosin106@gmail.com

consumer. Therefore, research is no longer based on the production of high-quality cheese but more on the commercialization of cheese as a functional food. Technology is needed for gentle processing to retain or even accumulate desired nutrients and to remove undesired compounds. Since more and more individuals would like to control their health via custom-made food, the worldwide market for functional food is one of the fastest-growing markets in the world (FAO/WHO, 2002).

Recent advances in nutrition science have highlighted the contribution of cheese to nutrition and health. Cheese is a rich source of essential nutrients; in particular, proteins, bioactive peptides, amino acids, fat, fatty acids, vitamins and minerals. Peptides were also detected in specific cheese varieties in significant quantities (Oladapo and Ogunekan, 2015). The high concentration of essential amino acids in cheese contributes to the growth and development of the human body. Despite the presence of a notable amount of saturated and trans-fatty acids, there is no clear evidence relating the consumption of cheese to any disease.

Conjugated linoleic acid and sphingolipids present in cheese may have anti-carcinogenic properties (Romeih et al., 2002). The high concentration of calcium in cheese is well known to contribute to the formation and maintenance of strong bones and teeth, but also shows a positive effect on blood pressure and helps in losing weight in combination with low-energy diets (Romeih et al., 2002). Cheese is an important dairy product and an integral part of a healthful diet due to its substantial contribution to human health. Natural cheese should be stored at suitable temperatures to ensure good quality (Aly et al., 2012).

Freeze drying of cheese helps to adequately conserve the proximate qualities of cheese which have the potential to ensure an adequate diet and ensure the good health of Nigerians. This contributes to the economic development of the nation because adequate nutrition is a basic requirement for economic development since an underfed nation is an underproductive nation. Many Nigerian families depend on the use of soy cheese and cow milk cheese as a cheap source of protein, mineral and vitamin in their day to day diet which helps to give a more balanced diet (Akinola, 2003). The objective of this study is to determine the proximate composition of packaged freeze-dried cow milk cheese and soy milk cheese in storage.

2 Materials and methods

One thousand five hundred grams (1,500 g) of soybeans and three litres (3 L) of fresh cow milk was purchased at Kure Market Minna, Niger State. Soy cheese and cow milk cheese used for this study were produced in the Crop Processing and Storage Laboratory of the Department of Agricultural and Bioresources Engineering, Federal University of Technology, Minna, Niger State, Nigeria.

2.1 Reagents and instruments

The reagents used for this research are distilled water, hydrochloric acid, concentrated sulphuric acid and petroleum ether. The instruments used for this research study are a sealing machine, Petri-dishes, desiccator, digestion block, Kjeldahl apparatus, filter paper, beaker, electronic weighing balance and beaker.

2.2 Method of milk production

The methodology used for the production of the fresh cow milk cheese was as prescribed by Amano (2013). The top layer of the milk was skimmed off to reduce the fat content of the milk. The milk was then pasteurized to about 70°C to destroy most of the bacteria present and also to increase yield through precipitation of the whey proteins (Adewumi and Ahmed, 2013), Lemon juice (Coagulant) was diluted with an equal quantity of clean fresh water for uniform distribution. About 30 mL of lemon juice per liter of milk was added and stirred after adding the lemon juice and the curd was allowed to settle for 15 minutes. The curd was separated from the whey by draining through a muslin (cheese) cloth. While draining the whey, the curd was stirred to prevent excess matting (Adeneye, 1989).

The curd was transferred to a mould (container) lined with muslin (cheese) cloth. The curd was wrapped with the muslin (cheese) cloth and a wooden follower was fitted

neatly inside the mould to enable the curd to be pressed (Adewumi and Ahmed, 2013). The curd was pressed by placing metal weights on top of the wooden follower. The cheese was removed from the mould and then cut into sizes of 3 × 3 cm dimension and thickness of 0.3 cm and was taken to the laboratory and freeze-dried.

The freeze-dried samples were then packaged in the different packaging materials (Sterile tightly covered glass jar, sterile tightly covered plastic container and sterile polythene film) for proximate composition analysis.

The production of the soy cheese from soybeans was carried out as prescribed by Connor (2015). About 1000 g of properly cleaned soybeans were soaked in water for 8-10 hours after which the soybeans were dehulled, then unground and mixed with clean water. A sieve was used to separate the milk from the chaff in the mixture. The milk was pasteurized and allowed to cool while the coagulant (Lemon juice) was added to the milk to form a curd. The wrapped cheese curd was pressed in a mould to remove the water present in the curd. The hardened cheese was then cut into sizes of 3 × 3 cm dimension and thickness of 0.3 cm. The soy cheese was then taken to the laboratory and freeze-dried. The freeze-dried samples were then packaged in the packaging materials for further analysis.

2.3 Experimental set-up

The experiment was carried out with samples of the cow milk cheese and soy cheese produced from fresh cow milk and soybeans. The freshly prepared cheese samples were cut cow milk cheese was divided into six portions of 100 g each while the cut soy cheese was also divided into six portions of 100 g each. With the initial properties of fresh cow milk cheese and soy cheese determined. The samples were open freeze-dried in the lyophilizer for 30 minutes at -28^{0}C with the compressor on, immediately after freezing; the freeze samples were subjected to low pressure with the vacuum switched on alongside the compressor to start drying. During the drying process, water was seen boiling off or subliming from all the frozen cheeses at a lower pressure of 14 Pascal and this was done for six hours for ten days (Oladapo and Ogunekan, 2015)

The initial properties of the freeze-dried samples were determined and 100 g of each sample were packaged in a sterile tightly covered glass jar, sterile tightly covered plastic container and sterile polythene film while the samples left were the unpackaged samples which serve as the control sample. The experiment was carried out using a randomized block design of three packaging types and three months storage duration at three replicates ($3^3 = 27$) for the cow milk and soy milk cheese samples. Samples were analyzed for their nutritional, microbial and sensory qualities monthly during the storage period. Data obtained were analyzed statistically to determine the effect of the packaging materials and storage durations on the proximate composition of freeze-dried cheese samples.

2.4 Proximate analysis

The proximate composition of samples A (cow milk cheese) and B (soy milk cheese) was determined according to the method described by the Association of Official Analytical Chemists (AOAC, 2000). The procedures for the determination of the proximate properties of cow milk and soy cheese are as follows:

2.4.1 Determination of moisture content

The petri-dish was washed thoroughly and dried in an oven for few seconds and removed, cooled to room temperature in the desiccators. The Petri-dishes were weighed using the electric weighing balance and their corresponding weight was recorded as W_1. Five grams (5 g) of the sample was measured and added to the Petri-dishes, the weight of the petri-dish and the sample was recorded as W_2. The Petri-dishes (containing their respective samples) was dried in an oven at 105^{o}C until constant weight (AOAC, 2000). After the drying time elapsed, the samples were removed from the oven and cooled in the desiccators to room temperature, while they are reweighted one after another and the new weight (Weight of Petri-dishes +dried sample) was recorded as W_3. The moisture content or percentage moisture (dry basis) for each sample was then calculated as:

$$\text{Moisture content} = \frac{W2-W3}{W2-W1} \times 100\% \quad (1)$$

Where:

W_1= Weight of petri-dish, g.

W_2= Weight of petri-dish and initial sample, g.

W_3= Weight of petri-dish and dried sample, g.

2.4.2 Determination of ash content

Three porcelain cubicles are thoroughly washed, heated, cooled in desiccators and weighed using the electronic weighing balance and the cubicles weight were recorded as W_1. Two grams (2 g) of each sample were added to its corresponding crucibles, the new weight of the crucible and the samples was recorded as W_2. After this, the samples were heated in a muffle furnace at 550°C for two hours to ash according to the American Association of Cereal Chemist method (AACC, 1999). At the end of the ashing period, the samples were light grey in colour. Removing the sample with the aid of tongs, the samples were cool in desiccators for some minutes before weighing. After cooling, the samples were weighed and the respective weights recorded as W_3. The percentage ash for each sample was then calculated as:

$$\% \text{ Ash (dry basis)} = \frac{W3-W1}{W2-W1} \times 100\% \quad (2)$$

Where:

Wl = Weight of crucible (g), W2 = Weight of crucible and initial sample (g), W3 = Weight of crucible and dried sample (g).

2.4.3 Determination of fat content

The fat content was determined by the procedure of AOAC (2000). Three 250 mL beakers were thoroughly washed, heated and cooled in desiccators. Three filter papers were selected and the corresponding weights were recorded as W_1. Two grams (2 g) of each sample measured into each of its corresponding filter paper and the new weight recorded as W_2 approximately. The filter paper with their respective sample in them was then neatly folded and closed in a manner that the sample was perfectly locked in them. Each of the dried beakers was filled with about 300 mL of petroleum ether boiling point 40°C-60°C. The Soxhlet apparatus was then assembled, each filter was placed in each extraction chamber of the entire Soxhlet set up, and the top controlling the continuous flows of water into the condenser was open. The power was on and the heating temperature was regulated to 50°C until the petroleum ether in the boiling flask started to boil, then the heating temperature was regulated down to 30°C. The apparatus was allowed to reflux for **six** hours, at the end of the stipulated time (**six** hours). The filter paper was removed carefully and taken to be dried in an oven for an hour at 105°C after which it was then cooled in a desiccator for some minutes, the new weights of the filter paper along with their contents are then measured again using the electric weighing balance and the weights measured was recorded as W_3. Finally, the percentage of fat was then calculated using the formula:

$$\% \text{ of fat} = \frac{\textbf{weight of Fat (W3−W1)}}{\textbf{original Sample (W2−W1)}} \text{ x } 100\% \quad (3)$$

2.4.4 Determination of crude protein content

About 0.5 g of each sample was weighed into three Kjeldahl flasks; 20 cm^3 conical flask, H_2SO_4, and 0.98 g of selenium tablet were added to each sample in its tube to act as a catalyst. The mixture was then heated at a low temperature for about 15 minutes and then increased to a higher temperature for 30 minutes and then at extra-high temperature until the sample was digested; at this stage, the solution was clear and colourless. The samples are then allowed to cool for a while. This was followed by the distillation of each sample using a Kjeldahl distillation setup. 5 mm of 2% Boric acid was prepared and poured into a 100 ml conical flask (as a receiving flask), three drops of mix indicator (Bromocresol Green and methyl) was added to the receiving flasks. The receiving flask was then placed under a condenser such that the tip of the condenser tube was below the surface of the boric acid. 5 mL of the digested sample was then pipetted into the body of the apparatus via the small funnel aperture and washed down with distilled water followed by 5 mL of 60% NaOH solution. Steam was passed continuously through the set-up for seven minutes to collect enough ammonium sulphate after which the receiving was removed and the tip of the condenser washed down into the flask. The

condenser water was also removed, the distillate or solution in the receiving flask was then titrated using 0.05 m hydrochloric acid and the titer value was recorded as T_1. The percentage of Nitrogen was then calculated as:

$$\% \text{ of Nitrogen} = \frac{T \times M \times 0.014 \times V}{W} \times 100\% \quad (4)$$

Where: M = molarity of acid (mol/L), V = 10, T = Control titre (mL), W = % of crude protein = % of nitrogen x conversion factor protein conversion factor = 6.23.

2.4.5 Carbohydrate

carbohydrate (%)= 100% - (% of fat + % of crude protein + % of Ash + % of crude fibre)

2.5 Statistical analysis

All experiments were carried out in three replicates. Data obtained were analyzed statistically using SPSS 20.0 Statistical Package to determine the analysis of variance (ANOVA) and the Duncan multiple range test to separate the means (Nwakuba et al., 2020). The packaged cow milk and soy milk cheese used for the experiment is shown in Figures 1 and 2, respectively.

Figure 1 Packaged cow milk cheese.

Figure 2 Packaged soy milk cheese

3 Results and discussion

3.1 Effects of freeze-drying on the proximate composition of stored freeze-dried cheese samples

The results of the effect of freeze-drying and storage duration on the proximate composition of freeze-dried cow

milk cheese and the ANOVA are presented in Tables 1 and 2 whereas the proximate composition of freeze-dried soy cheese and the ANOVA are presented in Tables 3 and 4.

Table 1 Effect of freeze-drying on the proximate composition of packaged freeze-dried cow milk cheese

Sample	Storage Duration	Moisture Content (%)	Ash (%)	Protein (%)	Fat (%)	CHO (%)
Fresh Cow milk Cheese		54.02±0.10^{a}	6.40±0.32^{c}	20.34±0.50^{b}	18.11±0.06^{a}	4.25±0.20^{a}
Freeze Dried Cow milk Cheese		4.28±0.10^{d}	32.72±0.12^{a}	32.24±0.28^{c}	4.05±0.98^{b}	26.86±0.90^{c}
Sample Packaged in Glass Jar	1	4.28±0.10^{d}	32.70±0.14^{a}	32.23±0.02^{c}	4.13±0.31^{b}	26.69±0.22^{c}
	2	4.29±0.50^{d}	32.67±0.24^{a}	32.20±0.00^{c}	4.18±0.01^{b}	26.63±0.10^{c}
	3	4.30±0.55^{d}	32.63±0.12^{a}	32.19±0.11^{c}	4.21±0.60^{b}	26.58±0.28^{c}
Sample Packaged in Plastic Jar	1	4.30±0.0.1^{d}	31.75±0.12^{a}	30.12±0.50^{c}	4.01±0.48^{b}	26.23±0.90^{c}
	2	4.32±0.31^{d}	31.72±0.17^{a}	30.10±0.11^{c}	4.06±0.20^{b}	26.16±0.21^{c}
	3	4.34±0.26^{d}	31.70±0.32^{a}	30.08±0.04^{c}	4.10±0.25^{b}	26.11±0.02^{c}
Sample Packaged in Polyethylene film	1	4.32±0.10^{d}	31.72±0.35^{a}	31.28±0.03^{c}	4.20±0.80^{b}	25.61±0.35^{c}
	2	4.33±0.32^{d}	30.68±0.58^{a}	31.23±0.90^{c}	4.26±0.04^{b}	25.42±0.28^{c}
	3	4.35±0.06^{d}	30.60±0.24^{a}	31.20±0.98^{c}	4.32±0.06^{b}	25.33±0.29^{c}
Control Sample	1	24.35±0.10^{c}	15.01±0.05^{b}	18.60±0.28^{b}	8.05±0.69^{b}	16.54±0.58^{b}
	2	30.29±0.12^{c}	8.12±0.16^{c}	10.15±0.51^{a}	12.16±0.51^{a}	10.41±0.02^{a}
	3	38.20±0.50^{b}	3.04±0.33^{c}	3.09±0.11^{a}	20.42±0.46^{a}	4.26±0.48^{a}

Note: Value followed by the same superscript alphabet are not significantly different at (P<0.05) along the column. Values are Mean ± SEM of triplicate determination.

Table 2 ANOVA of the proximate composition of freeze-dried cow milk cheese

Composition		Sum of Squares	Df.	Mean Square	F	Sig.
MC	Between Groups	5384.210	5	1076.842	607622.428	.000
	Within Groups	.021	12	.002		
	Total	5384.231	17			
Protein	Between Groups	2450.256	5	490.051	77376.521	.030
	Within Groups	.076	12	.006		
	Total	2450.332	17			
Ash	Between Groups	1850.246	5	370.049	3700491.200	.010
	Within Groups	.001	12	.000		
	Total	1850.247	17			
Fat	Between Groups	1011.582	4	252.895	2528954.400	.020
	Within Groups	.001	10	.000		
	Total	1011.583	14			
CHO	Between Groups	1024.011	4	256.003	2021074.000	.001
	Within Groups	.001	10	.000		
	Total	1024.012	14			

Table 3 Effect of freeze-drying on the proximate composition of packaged freeze-dried soy cheese

Composition		Sum of Squares	Df.	Mean Square	F	Sig.
MC	Between Groups	5927.628	4	1481.907	14819070.60	.000
	Within Groups	.001	10	.000		
	Total	5927.629	14			
Protein	Between Groups	1950.595	5	390.119	3901189.700	.020
	Within Groups	.001	12	.000		
	Total	1950.596	17			
Ash	Between Groups	1577.621	4	394.405	4550830.692	.000
	Within Groups	.001	10	.000		
	Total	1577.622	14			
Fat	Between Groups	476.833	4	119.208	2823.501	.010
	Within Groups	.422	10	.042		
	Total	477.255	14			

CHO	Between Groups	1161.712	4	290.428	2904280.500	.001
	Within Groups	.001	10	.000		
	Total	1161.713	14			

Note: Values followed by the same superscript alphabet are not significantly different at (P<0.05) along the column. Values are Mean ± SEM of triplicate determination.

Table 4 ANOVA of the proximate composition of freeze-dried cow milk cheese

Sample	Storage Duration	Moisture Content (%)	Ash (%)	Protein (%)	Fat (%)	CHO (%)
Fresh Soy Cheese		50.89±0.12^{a}	6.31±0.31^{c}	22.05±0.02^{b}	19.02±0.58^{a}	4.06±0.10^{a}
Freeze Dried Soy Cheese		4.19±0.46^{d}	30.98±0.55^{a}	34.84±0.31^{c}	4.30±0.29^{b}	24.72±0.01^{c}
Sample Packaged in Glass Jar	1	4.18±0.06^{d}	31.92±0.24^{a}	35.82±0.55^{c}	4.32±0.27^{b}	24.83±0.80^{c}
	2	4.20±0.14^{d}	32.89±0.12^{a}	34.80±0.02^{c}	4.36±0.02^{b}	24.80±0.31^{c}
	3	4.23±0.12^{d}	33.35±0.26^{a}	33.77±0.50^{c}	4.41±0.58^{b}	24.76±0.92^{c}
Sample Package in Plastic Jar	1	4.20±0.06^{d}	30.90±0.55^{a}	35.80±0.03^{c}	4.35±0.11^{b}	24.90±0.17^{c}
	2	4.25±0.12^{d}	32.40±0.28^{a}	34.76±0.12^{c}	4.39±0.31^{b}	24.84±0.50^{c}
	3	4.28±0.35^{d}	33.09±0.31^{a}	33.73±0.01^{c}	4.45±0.55^{b}	24.80±0.12^{c}
Sample Packaged in Polyethylene film	1	4.22±0.00^{d}	31.60±0.12^{a}	35.03±0.04^{c}	4.35±0.14^{b}	24.88±0.98^{c}
	2	4.26±0.31^{d}	32.28±0.46^{a}	34.64±0.28^{c}	4.40±0.02^{b}	24.82±0.12^{c}
	3	4.32±0.58^{d}	33.00±0.11^{a}	33.18±0.12^{c}	4.47±0.57^{b}	24.77±0.55^{c}
Control Sample	1	11.32±0.12^{c}	15.52±0.04^{b}	17.43±0.02^{b}	10.12±0.12^{b}	18.13±0.56^{b}
	2	20.15±0.03^{c}	8.70±0.12^{c}	10.08±0.12^{a}	16.05±0.05^{a}	11.21±0.31^{b}
	3	33.68±0.50^{b}	3.25±0.58^{c}	3.25±0.90^{a}	22.90±0.28^{a}	5.62±0.01^{a}

3.1.1 Effect of packaging materials and storage duration on the moisture content of stored freeze-dried cheeses

The high moisture content of cheese makes it susceptible to microbial contamination and rapid deterioration (Belewu, 2007). However, freeze-drying is known to decrease the water activity of food samples, thus, protecting them against microbial activity and increase the storage life of food. Statistical analysis shows that freeze-drying had a significant effect ($p < 0.05$) on the moisture content of the fresh cheese samples as the moisture content decreased significantly after freeze-drying (Tables 2 and 4). Statistically, there was no significant difference in the moisture contents of the freeze-dried cow milk cheese and soy milk cheese packaged in a glass jar, plastic container and polyethene film during the period of storage from Tables 1 and 3.

Hence, packaging material and storage duration had no significant effect on the moisture content of the stored samples. This is probably due to the impermeability of the packaging materials to surrounding air and moisture while the moisture content of the unpackaged samples (control sample) increased significantly throughout storage. The insignificant difference in moisture content during storage results in the inactivity of the micro-organisms and minimal spoilage which consequently increases shelf life (Gropper and Smith, 2009).

3.1.2 Effect of packaging materials and storage duration on the ash content of stored freeze-dried cheese samples

The ash content gives a measure of the total amount of inorganic compounds like minerals present in a food sample (Odenigbo and Obizoba, 2004). A high percentage of ash content was observed in the freeze-dried cheese samples. This is due to the accumulation of the cheese minerals through the sublimation of the moisture content and lipid in the fresh cheeses samples (Food and Nutrition Board [FNB], 2000). Statistical analysis shows that freeze-drying had a significant effect ($p < 0.05$) on the ash content of the fresh cheese samples as the ash content increased significantly after freeze-drying (Tables 2 and 4).

Statistically, there was no significant difference in the ash contents of the freeze-dried cow milk cheese and soy milk cheese packaged in a glass jar, plastic container and polyethene film during the period of storage (Tables 2 and 4). Hence, packaging material and storage duration have no significant effect on the ash content of the stored freeze-dried samples. The increase in the ash content after freeze-drying could be a result of some inorganic minerals trapped in the cheese samples during freeze-drying. Similar findings have been reported for fish (Marques and Prado, 2011). The ash content of the unpackaged samples (control

sample) decreased significantly throughout storage.

3.1.3 Effect of packaging materials and storage duration on the protein content of stored freeze-dried cheese samples

Dairy products particularly cheeses are good sources of protein, a higher percentage of protein content was observed in soy cheese and cow milk cheese. The nutritional content of cow milk cheese and soy cheese showed its appreciable nutritional status especially of protein content. Proteins are essential organic compounds that help in building and maintaining all tissues in the body (Andrew, 2010).

Statistical analysis shows that freeze-drying had a significant effect on the protein content of the fresh cheese samples as it increased significantly ($p < 0.05$). There was no significant difference in protein content of the packaged cheese samples during the period of storage while the protein content of the unpackaged samples (control sample) decreased significantly throughout storage (Tables 1 and 3). Protein forms an important part of enzymes, fluids and hormones of the body and also helps form antibodies to fight infection and supplies energy (Oladapo and Ogunekan, 2015).

3.1.4 Effect of freeze-drying, packaging materials and storage duration on the fat content of stored freeze-dried cheese samples

The fat content gives a measure of the total lipids present in the food sample. The low-fat content of the freeze-dried cheese samples has an advantage as the cheese samples will be less susceptible to rancidity. The result showed that freeze-drying decreases the fat content of the fresh cheese samples significantly ($p < 0.05$) from Tables 2 and 4. Statistically, there was no significant difference in the fat contents of the freeze-dried cow milk cheese and soy milk cheese packaged in a glass jar, plastic container and polyethene film during the period of storage. Hence, packaging materials and storage duration had no significant effect on the fat content of the stored cheese samples.

Dietary fats represent the most compact chemical energy available to man (Kummerow, 2015). Low-fat content in freeze-dried cheeses is a desirable property as excess fat consumptions have been implicated in the aetiology of certain cardiovascular disease such as cancer and ageing (Akinola, 2003). The fat content of the unpackaged samples (control sample) increased significantly throughout storage.

3.1.5 Effect of freeze-drying, packaging materials and storage duration on the carbohydrate content of stored freeze-dried cheese samples

Carbohydrates are the most abundant organic material on earth (Marshal, 1992). Statistical analysis shows that freeze-drying had a significant effect on the increase in carbohydrate content of the freeze-dried cheese samples ($p < 0.05$) from Tables 2 and 4. Statistically, there was no significant difference in the carbohydrate contents of the stored cow milk cheese and soy milk cheese packaged in a glass jar, plastic container and polyethene film during the period of storage. Hence, packaging materials and storage duration have no significant effect on the carbohydrate content of the stored cheese samples (Tables 3 and 4).

The higher carbohydrate values for freeze-dried samples indicates that the hydrolysis of complex carbohydrate by freezing drying release more absorbable carbohydrate (Odenigbo and Obizoba, 2004). These high carbohydrate levels could mean high energy provided by the cheese sample (Andrew, 2010). The carbohydrate content of the unpackaged samples (control sample) decreased significantly throughout storage.

4 Conclusion

The fresh cow milk and soy milk cheese are rich in protein, ash content, carbohydrate, fat and moisture content. The carbohydrate, protein and ash content of the fresh cheeses increased significantly ($p < 0.05$) while the moisture content and fat decreased significantly ($p < 0.05$) when freeze-dried.

Statistically, there was no significant difference in the proximate qualities of the stored cheese samples during the storage period (three months) irrespective of the packaging material used. It is therefore concluded that freeze-drying increases the carbohydrate, protein, ash and decreases

moisture content and fat concentration of cheeses as well as extend the shelf life. Polythene film is recommended to be more suitable in terms of cost, availability, compatibility and weight.

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