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Mineral Composition Of Stored Freeze Dried Cheeses In Selected Packaging Materials

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ABSTRACT

The mineral composition of stored freeze dried cow milk cheese and soy cheese in selected packaging materials was investigated. 300g each of fresh cow milk and soy milk cheese was prepared and cut into sizes of 2x2cm dimension and a thickness of 0.2cm. The initial properties were determined using 50g each of the cheeses while the remaining 250g was 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 sterilized glass jar, plastic jar and polythene film while the unpackaged sample was used as the control sample. The samples were stored at ambient room conditions for 3 months. Samples were analyzed for mineral composition monthly during the storage period. Data obtained were analyzed statistically to determine the effect of the packaging materials and storage durations on the mineral composition of freeze dried cheese samples. Result of the mineral composition for the fresh cow milk and soy cheese for potassium, magnesium, iron, calcium, and sodium were 7.0±0.3, 5.22±0.11, 6.32±0.12, 11.12±0.40, 3.30±0.06 and 7.04±0.04, 5.14±0.14, 6.20±0.32, 10.76±0.60, 3.52±0.85 respectively while the result for the freeze dried cow milk and soy cheese before storage were 7.12±0.12, 5.20±0.40, 5.45±0.12, 15.85±0.03, 5.20±0.40 and 7.19±0.32, 5.10±0.60, 5.32±0.11, 13.40±0.35, 5.40±0.32 respectively. Results showed that statistically, there was no significant difference in the mineral composition of the stored cheese samples during the storage period (3 months). The packaging material type used and storage duration has no significant effect on the minerals of the cow milk and soy milk cheeses after 3 months of storage. This indicates that all the packaging material types used retain the mineral composition of freeze dried cheese.

Keywords: cheese, freeze drying, mineral composition, packaging materials, storage duration.

INTRODUCTION

Consumers are shifting towards 'light' foods with low calories and adopting 'functional foods' that is going to improve their health and well-being too. Soybean seed contains about 40% protein, 30% carbohydrates, 20% oil and 10% mineral (Andrew, 2010). Owning to its nutritional value there is a growing demand for soy products such as soymilk, soy oil, soy cake, and soy cheese like soybean curd rich in protein. The medicinal nature of soybean is extremely essential in building body immune system. Soy food has been reported to provide significant, but not total protection against heart disease, high blood pressure, stroke, ulcer, menopause, diabetes and cancer (Andrew, 2010). 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 under productive 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 help to give a more balanced diet (Connor, 2003).

The most important domestic processed forms of soy beans are soy milk, soy custard and soy cheese (Bonazzi, 2003).The soy based products produced by commercial processors are soy oil, soy cake and meal, infant foods, instant foods, soy flour, soy gum and flax. The infant and instant foods industries also utilize the bean in producing soy flour, baby foods, breakfast foods, snacks and other confectioneries. In addition, feed mills utilize between 8.5 - 11 per cent soy for poultry mash and between 18-49 per cent for poultry concentrates; instant food companies utilize between 20 - 80 per cent soy depending on

products while infant food companies utilize 30 per cent soy in their products (Connor, 2003).

Soy cheese and Cow milk cheese are widely consumed in Africa (Akinola, 2003). Despite the widespread consumption of these cheeses, information is lacking on the effect of packaging and preservation methods on its mineral contents. The poor state of cheese packaging in Nigeria is a challenge that affects the shelf life of the cheese and do contaminate the packaged cheese. The use of materials such as calabash containers and bowls is a common practice by local cheese processorsand sellers. However, packaging plays an important role in maintaining the quality and extending the shelf life of the stored produce. Packaging material protects the products against variety of hazard which might have adverse effect on the quality of the produce during handling, distribution and storage (Brennan and Day, 2006).

Soy cheese and cow milk cheese get spoilt or rancid after some days; therefore there is a need to extend the shelf life by destroying or inhibiting micro-organisms and slowing down enzyme activity (Akinola, 2003). One of the ways by which cheese can be preserved is by freeze drying method, and this method can transform the cheeses into forms that have longer shelf life rather than keeping them in fresh forms which are perishable (Akinwumi, 2008). Most of deterioration and microbiological reaction are stopped because of the absence of liquid water and the low temperature (approx. 20°C) used during freeze drying operation (Adewumi, 2009). In freeze dried products shrinkages are eliminated, minimum loss of flavour, aroma, vitamins, and near-perfect preservation results are obtained. The aim of this work is to determine the mineral composition of stored freeze dried cheeses in selected packaging materials.

MATERIALS AND METHODS

One Thousand Five Hundred grams (1500g) of soy beans and Three litres (3l) of fresh cow milk was purchased at Kure Market Minna Niger State. Soy cheese and cow milk cheese used for this study was produced in the Crop Processing and Storage Laboratory of the Department of Agricultural and Bioresources Engineering, Federal University of Technology, Minna, Niger State, Nigeria.

Reagents and Instruments

The reagents used for this research study are distilled water, hydrochloric acid and concentrated nitric acid.

The instruments used for this research study are sealing machine, spectrophotometer, flame photometer, volumetric flask, sampling bottle and furnace.

Methodology

The cow milk cheese production was carried out by heating the cow milk to about 65°C to destroy most of the bacteria present and also to increase yield through precipitation of the whey proteins (Belewu, 2007), Lemon juice (coagulant) was added and stirred. Stirring continued for about three minutes after adding the lemon juice and then the curd was allowed to settle for 15 minutes. The curd was separated from the whey by draining through a muslin (cheese) cloth (Akinola, 2003). The curd was transferred to a container lined with muslin (cheese) cloth and the curd was pressed by placing metal weights on top. The cheese was removed from the muslin cloth and then cut into sizes of 2x3cm dimension and 0.2cm thickness. It was then taken for freeze drying. The freeze dried samples were packaged in different packaging materials (Sterile tightly covered glass jar, sterile tightly covered plastic container and sterile polythene film) for mineral composition analysis. The flow chart of the unit operations in freeze drying and storing of the cow milk cheese is presented in Figure 1.

The soy cheese production was carried out as prescribed by Connor, 2003. About 1000g of properly cleaned soy beans was soaked in water for 10-12 hours after which the soybeans was de-hulled, grinded and water was added. A sieve was used to separate the milk from the chaff in the mixture. The milk was pasteurizes and allowed to cool while the coagulant was added to the milk to form curd. The curd was wrapped with the muslin (cheese) cloth and pressed in a mould to remove the water present in the curd (Tofu, 2013). The hardened cheese was cut into the same size of 2x2cm dimension and of 0.2cm thickness and later taken to the laboratory for

freeze drying. The freeze dried samples were packaged in the packaging materials for mineral composition analysis. The flow chart of the unit operations in drying and storing of the soy milk cheese is presented in Figure 2.

Experimental set up

The experiment was carried out with samples of cow milk cheese and soy cheese produced from fresh cow milk and soybeans with lemon juice as coagulant. The freshly prepared cheeses were cut into their various dimensions and the cut cow milk cheese was divided into 6 portions of 50g each while the cut soy cheese was also divided into 6 portions of 50g each. With the initial properties of fresh cow milk cheese and soy cheese determined. The samples were freeze dried in the lyophilizer for 4hours at -28^{0}C then the freezed samples were subjected to low pressure with the vacuum switched on alongside with the compressor to start drying (Belewu, 2007). During the drying process, water was seen boiling off or subliming from all the freezed cheeses at a lower pressure of 14 pascal and this was done for six hours for ten days (Andrew, 2010).

The initial properties of the freeze dried samples were determined and 50g of each sample were packaged in 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 3 packaging types and 3 months storage duration at 3 replicates for the cow milk and soy milk cheese samples. Data obtained were analyzed statistically to determine the effect of the packaging materials and storage durations on the mineral qualities of freeze dried cheese samples.

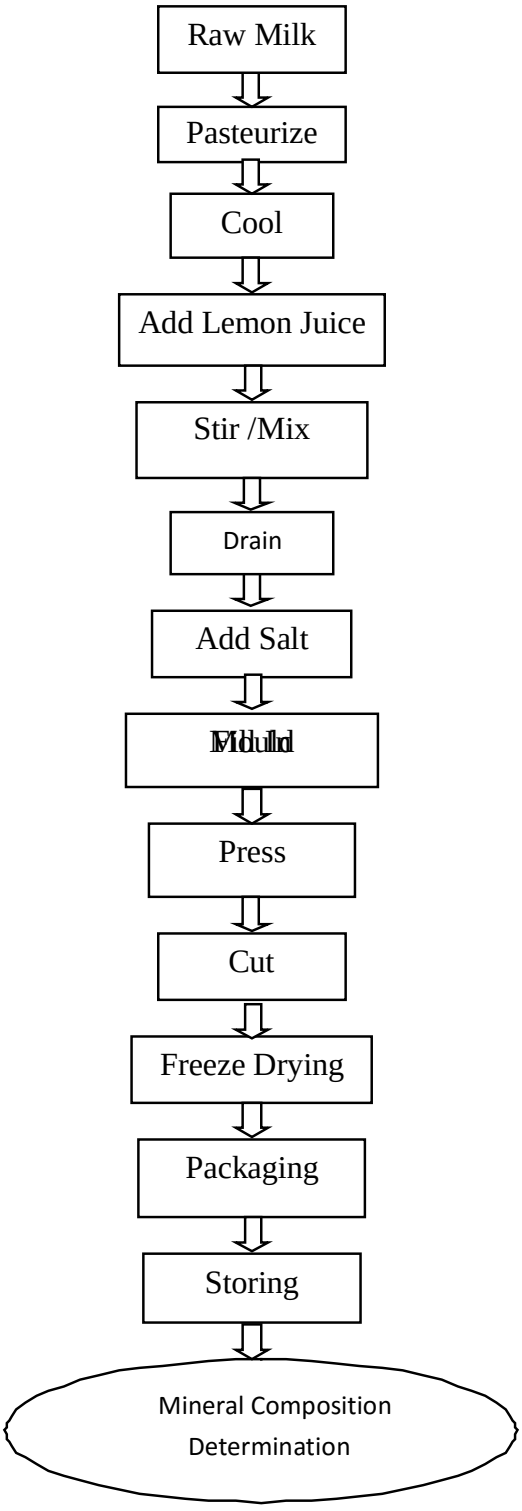

Figure 1: Flow chart of unit operations for the production of freeze dried cowmilk cheese.

DETERMINATION OF MINERAL COMPOSITION

The mineral 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 mineral composition of cow milk and soy cheese are as follows:

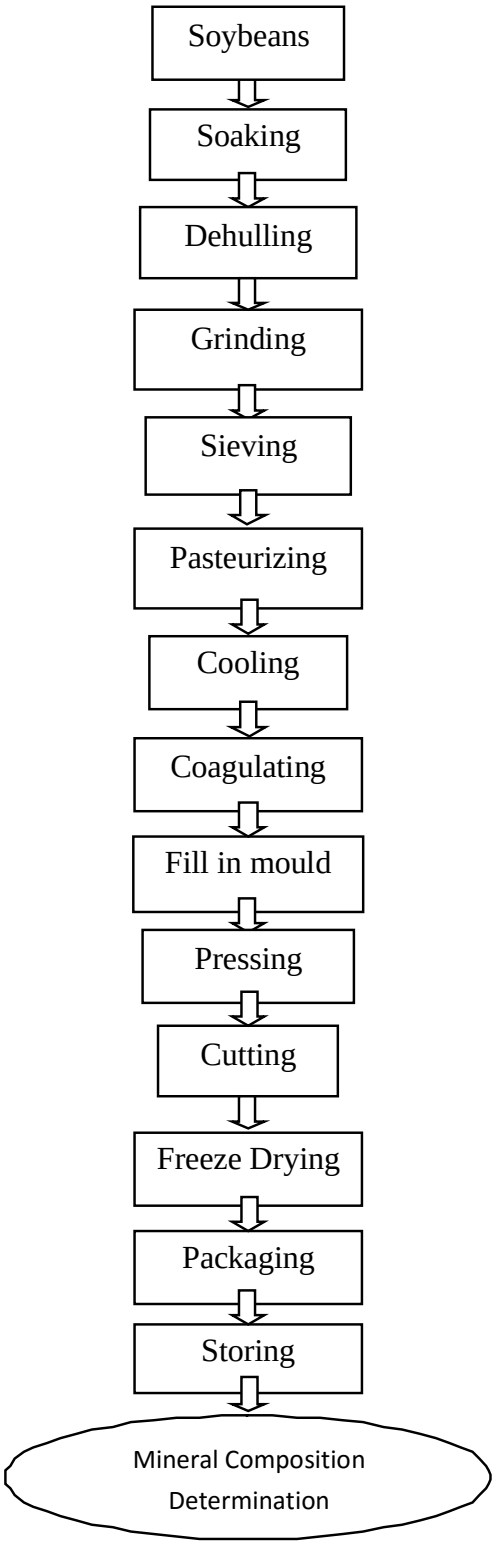

Figure 2: Flow chart of unit operations for the production of freeze dried soy cheese.

Determination of potassium concentration

About 0.5g of the sample was first digested with 500ml of acid mixture (650ml conc., HNO_2, 80ml per chloric acid; 20ml conc. H_2S0_4) and the sample was then heated until clear digestions was obtained and allowed to cool down. The digested sample was then diluted with 500ml distilled water, a stock solution containing 100mg/ml of K+ ions are prepared to dissolve 1.907g of Potassium chloride (KCl) in water. The potassium emissions measured in air acetylene flame. A calibration curve of potassium emission against concentration was drawn and reading was noted and recorded.

Determination of magnesium concentration

Five ml ***(5ml)*** aliquot of the sample solution was measured into a 100ml conical flask. 5ml ammonium chioride-ammonium hydroxide buffer solution was then added followed by 1ml of triethanolamine. Three drops of ***10%***Potassium cyanide (KCN) solution and few drops of Eriochrome Black T (EBT) indicator solution was then added. The content in the flask was then thoroughly mixed by shaking and then titrated with 0.02 Ethylene diamine tetraacetic acid (EDTA) solutions from a red to blue end point. Magnesium concentrations were then calculated.

Determination of iron concentration

Aliquots of standard sample and blank pipette into tubes and absorbance measured at 248nm using air-acetylene flame. Calibration curve of absorbance was then drawn against the concentration of iron to determine the iron concentration.

Determination of sodium concentration

One gram (1g)of the sample was weighed and placed in a crucible and subjected to ashing in furnace for an hour at 550^0c. After cooling in dessicator, a 2.5mL of 6N HNO3 was added to the crucible. The solution was filtered and diluted with 100mL distilled water. The solution was analyzed for sodium using Atomic absorption spectrophotometer.

Statistical Analysis

All experiments were carried out in three

replicate. Data obtained was 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.

RESULTS AND DISCUSSION

The results of the effect of packaging materials and storage duration on the mineral composition of freeze dried cow milk cheese and the analysis of variance (ANOVA) are presented in Table 1 and 2 while the mineral composition of freeze dried soy cheese are presented in Table 3 and 4 respectively.

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

Effect of packaging materials and storage duration on the potassium content of stored freeze dried cheese samples

The potassium content of the stored cheese samples ranged from 6.44 (Mg/100g) to 6.80

Table 1 Effect of freeze drying on the mineral composition of packaged freeze dried cow milk

Sample	Storage Duration	K(Mg/100g)	Mg(Mg/100g)	Fe(Mg/100g)	Ca(Mg/100g)	Na(Mg/100g)
Fresh Cow milk Cheese		7.0±0.03^{a}	5.22±0.11^{b}	6.32±0.12^{a}	11.12±0.40^{c}	3.30±0.06^{b}
Freeze Dried Cow milk Cheese		7.12±0.12^{a}	5.20±0.40^{b}	5.45±0.12^{a}	15.85±0.03^{c}	5.20±0.40^{b}
Sample Packaged in Glass Jar	1	6.81±0.32^{a}	5.13±0.32^{b}	5.42±0.06^{a}	15.82±0.22^{c}	5.24±0.50^{b}
	2	6.80±0.01^{a}	5.11±0.01^{b}	5.41±0.40^{a}	15.80±0.03^{c}	5.20±0.03^{b}
	3	6.77±0.03^{a}	5.10±0.42^{b}	5.38±0.60^{a}	15.77±0.12^{c}	4.98±0.24^{b}
Sample Packaged in Plastic Jar	1	6.80±0.60^{a}	5.15±0.12^{b}	5.44±0.60^{a}	15.78±0.20^{c}	5.20±0.50^{b}
	2	6.80±0.40^{a}	5.13±0.03^{b}	5.42±0.03^{a}	15.76±0.12^{c}	5.14±0.06^{b}
	3	6.78±0.32^{a}	5.11±0.06^{b}	5.40±0.45^{a}	15.75±0.65^{c}	5.10±0.22^{b}
Sample Packaged in Polyethylene film	1	6.83±0.42^{a}	5.12±0.12^{b}	5.42±0.42^{a}	15.81±0.65^{c}	5.21±62^{b}
	2	6.82±0.03^{a}	5.05±0.65^{b}	5.40±0.01^{a}	15.77±0.06^{c}	5.15±0.03^{b}
	3	6.80±0.60^{a}	4.92±0.40^{b}	5.39±0.32^{a}	15.76±0.42^{c}	4.98±0.40^{b}
Control Sample	1	5.12±0.32^{a}	4.0±0.12^{b}	4.38±0.03^{b}	10.01±0.01^{c}	4.08±0.12^{b}
	2	4.08±0.01^{b}	2.60±0.03^{a}	3.20±0.40^{b}	8.18±0.01^{b}	3.11±0.40^{b}
	3	2.32±0.06^{a}	1.93±0.42^{a}	2.08±0.12^{a}	4.06±0.06^{b}	2.03±0.32^{a}

Value followed by 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 mineral composition of freeze dried cow milk cheese

		Sum of Squares	df	Mean Square	F	Sig.
Potassium	Between Groups	43.898	5	8.780	636.207	.093
	Within Groups	.166	12	.014		
	Total	44.064	17			
Magnesium	Between Groups	24.536	5	4.907	1218.355	.105
	Within Groups	.048	12	.004		
	Total	24.585	17			
Iron	Between Groups	34.584	5	6.917	510.677	.080
	Within Groups	.163	12	.014		
	Total	34.747	17			
Calcium	Between Groups	218.766	5	43.753	5229.469	.001
	Within Groups	.100	12	.008		
	Total	218.867	17			
Sodium	Between Groups	22.003	5	4.401	244.181	.001
	Within Groups	.216	12	.018		
	Total	22.220	17			

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

Sample	Storage Duration	K(Mg/100g)	Mg(Mg/100g)	Fe(Mg/100g)	Ca(Mg/100g)	Na (Mg/100g)
Fresh Soy Cheese		7.04±0.04 [a]	5.14±0.14 [c]	6.20±0.32 [b]	10.76±0.60 [b]	3.52±0.85 [a]
Freeze Dried Soy Cheese		7.19±0.32 [a]	5.10±0.60 [c]	5.32±0.11 [b]	13.40±0.35 [c]	5.40±0.32 [a]
Sample Packaged in Glass Jar	1	6.80±0.03 [a]	4.90±0.60 [c]	5.30±0.30 [b]	13.32±0.02 [c]	5.28±0.40 [a]
	2	6.76±0.45 [a]	4.85±0.10 [c]	5.24±0.06 [b]	13.27±0.40 [c]	5.26±0.06 [a]
	3	6.70±0.12 [a]	4.81±0.40 [c]	5.19±0.12 [b]	13.22±0.35 [c]	5.23±0.10 [a]
Sample Packaged in Plastic Jar	1	6.76±0.22 [a]	4.88±0.10 [c]	5.28±0.35 [b]	13.30±0.14 [c]	5.20±0.12 [a]
	2	6.70±0.06 [a]	4.75±0.45 [c]	5.22±0.60 [b]	13.24±0.42 [c]	5.11±0.35 [a]
	3	6.58±0.10 [a]	4.63±0.11 [c]	5.13±0.12 [b]	13.17±0.21 [c]	5.0±0.60 [a]
Sample Packaged in Polyethylene film	1	6.72±0.18 [a]	4.81±0.11 [c]	5.20±0.13 [b]	13.30±0.06 [c]	5.21±0.20 [a]
	2	6.60±0.21 [a]	4.76±0.80 [c]	5.11±0.32 [b]	13.23±0.30 [c]	5.10±0.21 [a]
	3	6.44±0.16 [a]	4.70±0.06 [c]	5.01±0.22 [b]	13.11±0.12 [c]	4.98±0.35 [a]
Control Sample	1	3.03±0.11 [b]	3.10±0.42 [c]	3.32±0.23 [b]	6.08±0.32 [b]	3.03±0.35 [b]
	2	2.15±0.21 [b]	2.20±0.40 [b]	2.80±0.10 [a]	4.19±0.21 [a]	2.29±0.10 [b]
	3	1.40±0.10 [b]	1.86±0.05 [b]	1.95±0.30 [a]	2.82±0.11 [a]	1.14±0.11 [b]

(Mg/100g) which is satisfactory according to the recommended standard by FAO/WHO for milk and milk products. Statistical analysis shows that freeze drying has no significant effect on the potassium content of the fresh cheese samples while the potassium content of the unpackaged samples (control sample) decreased significantly over the period of storage.

There was no significant difference in the potassium content of the stored cheese samples during the storage period (Table 1 and 3). Hence, packaging materials and storage duration has no significant effect on the potassium content of the stored cheese samples. The insignificant difference of potassium during storage may be that the moisture and oxygen in the surrounding of the packaged materials could not penetrate to cause oxidative deterioration in the cheese sample.

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

Magnesium is known to promote bone and teeth health, and also is essential in enzyme systems in the body, consumption of cheese will result in strengthening of the bones and teeth of the consumers and improve metabolism (Food and Nutrition Board, 2001). Statistical analysis shows that freeze drying has no significant effect on the magnesium content of the fresh cheese samples. This is because freeze drying causes a quick evaporation of water from the cheese samples at a low temperature and longtime treatment which reduces oxidation and other side reactions, and thus preserving the nutritional values with increase in storage period (Odenigbo and Obizoba, 2004).

The magnesium content of the stored cheese samples ranged from 4.70 (Mg/100g) to 5.11 (Mg/100g) which is satisfactory according to the recommended standard by FAO/WHO for milk and milk products. Result showed there was no significant difference in the magnesium content of the stored cheese samples during the storage period as presented in Table 1 and 3. More so, the packaging materials and storage duration has no significant effect on the magnesium content of the stored cheese samples. The magnesium content of the unpackaged samples (control sample) decreased significantly over the period of storage.

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

Iron is known to be an essential part of red blood cells (haemoglobin) and enzymes (cytochromes). Due to the insignificant difference in iron content of the freeze dried cheese samples, consumption of freeze dried cheese will improve the blood haemoglobin levels and reduce the risk of anaemia in the consumer (Kirmaci *et al*, 2008). Statistical analysis shows that freeze drying had no significant effect on the iron content of the fresh cheese samples. There was no significant difference in the iron content of the cheese samples packaged in the different packaging materials during the storage period (Table 1 and 3). Hence, packaging materials and storage duration has no significant effect on the iron content of the stored cheese samples.

The iron content of the stored cheese samples ranged from 5.01 (Mg/100g) to 5.38 (Mg/100g) which is satisfactory according to the recommended standard for milk and milk products (FAO/WHO,2002). Neither the total iron content nor the nutrient density of the individual food constitutes an accurate guide for choosing dietary sources of iron (Adewumi, 2009). Rather the bioavailability of iron present in a meal, which depends on its form and the presence or absence of factors that influence absorption and the body's need for iron ultimately determine how much iron that is actually delivered to the body. The iron content of the unpackaged samples (control sample) decreased significantly over the period of storage.

Effect of packaging materials and storage duration on the calcium content of stored freeze dried cheese samples

A food product with high calcium content prevents bone and teeth disorder (Eric, 2013). Statistical analysis shows that freeze drying significantly ($P<0.05$) increase the calcium content of the fresh cheese samples in Table 2 and 4. The calcium content of the unpackaged samples (control sample) decreased significantly over the period of storage.

Table 4: ANOVA of the mineral composition of freeze dried soy cheese

Potassium	Between Groups	51.302	5	10.260	5322.410	.082
	Within Groups	.023	12	.002		
	Total	51.325	17			
Magnesium	Between Groups	26.334	5	5.267	2159.490	.100
	Within Groups	.029	12	.002		
	Total	26.363	17			
Iron	Between Groups	32.916	5	6.583	104.293	.060
	Within Groups	.757	12	.063		
	Total	33.673	17			
Calcium	Between Groups	342.989	5	68.598	128620.875	.001
	Within Groups	.006	12	.001		
	Total	342.995	17			
Sodium	Between Groups	32.261	5	6.452	2657.679	.001
	Within Groups	.029	12	.002		
	Total	32.290	17			

The calcium content of the stored cheese samples ranged from 13.11 (Mg/100g) to 15.82 (Mg/100g) which is similar to the calcium content of local freeze dried cheese by Okafor et al. 2017.

There was no significant difference in the calcium content of the stored cheese samples during the storage period (Table 1 and 3). Hence, packaging materials and storage duration has no significant effect on the calcium content of the stored cheese samples. Due to the sublimation of frozen water from the cheese samples at a low temperature and longtime treatment which reduces oxidation and other side reactions, the nutritional values are preserved with no significant changes during the storage period (Soroka, 2002).

Effect of packaging materials and storage duration on the sodium content of stored freeze dried cheese samples

Sodium ions are correlated to lactose to maintain osmotic equilibrium of milk with blood (Bonazzi, 2003). Statistical analysis shows that freeze drying significantly ($P<0.05$) increase the sodium content of the fresh cheese samples. The sodium content of the unpackaged samples (control sample) decreased significantly over the period of storage in Table 2 and 4.The sodium content of the stored cheese samples ranged from 4.98 (Mg/100g) to 5.24 (Mg/100g) which is satisfactory for a milk products (FAO/WHO, 2002).

Result showed there was no significant difference in the sodium content of the stored cheese samples during the storage period as presented in Table 1 and 3. The packaging materials and storage duration has no significant effect on the sodium content of the stored cheese samples. The insignificant difference of sodium during storage may be that the moisture and oxygen in the surrounding of the packaged materials could not penetrate to cause oxidative

deterioration in the cheese sample.

CONCLUSION

The fresh cow milk and soy milk cheese are rich in calcium, sodium, potassium, magnesium andiron. The potassium, calcium and sodium of fresh cheeses increased significantly ($P<0.05$) when freeze dried while magnesium and iron decreased significantly ($P<0.05$).

Statistically, there was no significant difference in the mineral composition of the stored cheese samples during the storage period (3 months) irrespective of the packaging material type used. It is therefore concluded that freeze drying increases the mineral concentration of cheeses and as packaging is essential for the retention of the mineral components. Polythene film is recommended to be more suitable in terms of cost, availability, compactibility and weight.

RECOMMENDATIONS

Further work should be carried out on the qualities of the rehydrated freeze dried cheese and comparative study should also be carried out using light polythene film, papers and other types of local packaging materials.

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