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Chemical stability of vacuum packaged West African cheese (Wagashie)

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Local West African cheese (Wagashie) samples from unpasteurized full-fat milk (UFFM), pasteurized full-fat milk (PFFM) and partially pasteurized skimmed milk (PPSM) were prepared and a fourth (control) was purchased from a local commercial producer. The study was to determine chemical changes of the Wagashie samples over a four week storage period. All the four Wagashie samples were vacuum-packaged at pressure of 11.1 bars and stored at 12°C. Chemical tests (moisture, crude proteins, fat, free fatty acid and pH) were conducted on week zero, one, two and four. Percent moisture (wet basis) and FFA, after the storage period, reduced and increased ($p< 0.05$) respectively. Percent protein (wet basis) remained unchanged ($p> 0.05$) in samples PPSM and PFFM but increased ($p< 0.05$) in the other two samples. Percent fat increased in PPSM and control but decreased in the other two samples ($p< 0.05$). pH of all the Wagashie samples reduced ($P< 0.05$) at the end of storage. The study showed that the greatest change in terms of the parameters considered occurred in the control after storage.

Key words: Wagashie, vacuum packaging, chemical stability.

INTRODUCTION

'Wagashie' is a cheese prepared from cow's milk and patronized by people in the West African sub-region. It can be described as soft unripened cheese because of its high moisture content of about 50% wet basis (Ashaye et al., 2006) and the fact that it is not allowed to go through the ripening stage before consumption (public opinion).

In preparing Wagashie cheese *Calotropis procera* juice extract, a milk protein coagulant, is added to warmed milk (Ogundiwin and Oke, 1983). The milk is gently stirred and the temperature increased slowly until it reaches the boiling point. At this stage a visible separation of the curds from the whey is observed. The pieces of curds are then collected into small raffia baskets that define the shape of the product; at this stage the product is called Wagashie.

Wagashie is a highly perishable product. It was observed by Ashaye et al. (2006) that the shelf life does not exceed three days. After the second day of storage, Wagashie under ambient temperature undergoes considerable undesirable chemical changes. These changes (moisture change, proteolysis and lypolysis) are caused by increased activity of the resident lactic acid bacteria and adventitious microbes. The moisture content reduces causing hardening; proteolysis sets in resulting in the sourness of the product and lypolysis occurs imparting a rancid aroma to it. The change in the composition is accompanied by changes in the sensory quality of the product (Appiah, 2000).

Studies have been carried out to improve upon the keeping quality of this nutritious soft cheese. In a study conducted by Appiah (2000), different concentrations of NaCl solution were applied to extend the shelf-life of Wagashie up to fifteen days. Similarly, application of preservatives like propionic acid and sodium benzoate (Joseph and Akinyosoye, 1997), biological plant extracts like *Afromomum danielli* (Ashaye et al., 2006), ginger and

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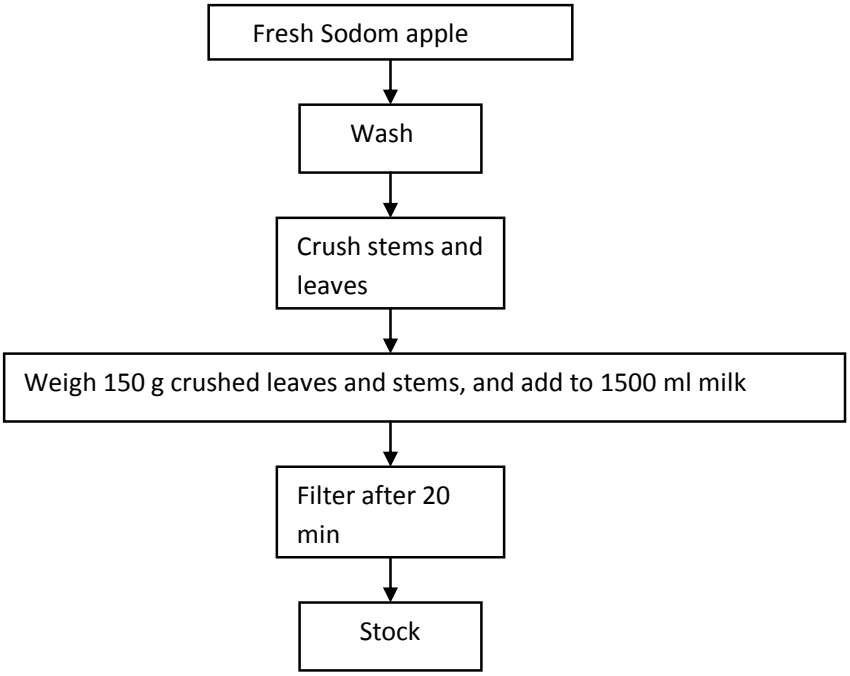

Figure 1. Stock preparation step.

garlic (Belewu et al., 2005) resulted in similar outcomes. However, these chemical additives change the taste of the Wagashie. Consumers are increasingly becoming aware of the dangers posed by chemically treated food products. Chemical additives such as preservatives, antioxidants, colourants etc added to foods and food products have been linked with many health problems such as allergies, and are believed to cause initiation of carcinogenesis (Halliwell et al., 1995).

Drying and smoking which are general methods for preserving cheese (Berg, 1988) have been employed, traditionally, to prolong the shelf-life of Wagashie; these methods affect the texture of the product.

An alternative to extending the shelf-life of Wagashie without drying, smoking or the use of chemicals is the application of vacuum packaging technology. Vacuum packaging is a type of modified atmosphere packaging where original air within the pack is evacuated and the pack sealed creating a vacuum around the product (Davies, 1991). The packaging material used retards the influx of oxygen and water vapour that cause spoilage of food products. As a result, very low amount of residual oxygen is left leading to a reduced oxidative and aerobic activity. The package also protects the food product from microbial contamination (Brody, 1989).

A combination of vacuum packaging and cold storage act synergistically to retard the growth of microbes that find their way into the product prior to packaging, thereby, retarding the chemical composition and sensory changes of the food; this extends the keeping quality. The present study is to determine the physicochemical changes of different treatments of vacuum packaged Wagashie.

MATERIALS AND METHODS

Sources of materials

Wholesome fresh milk was purchased from Amrahia Dairy Farm, and Animal Research institute, Council for Scientific and Industrial Research (CSIR), both situated in the Ga East District of Greater Accra region, Ghana. Clean high density flexible plastic pouches from Danica Plastic Ltd (Kasoa) in the Central region and aluminium foil from Mokola Market in the Greater Accra region were purchased.

Preparation of Wagashie

Three different samples of Wagashie were prepared; they were Wagashie from unpasteurized full-fat milk (UFFM), pasteurized partially skimmed milk (PPSM) and pasteurized full-fat milk (PFFM). A fourth product (D) that served as control was commercially purchased from the Nima Market in Accra, Ghana. The preparation of these Wagashie types was preceded by stock preparation.

Stock preparation

Fresh Sodom apple leaves and stems were washed and crushed in a mortar with a pestle. 1500 ml of fresh milk was added to 150 g of the crushed Sodom apple. The set-up was allowed to stand for 20 min after which the milk was filtered (Figure 1).

Milk treatment preceeding Wagashie preparation

Six litres each of milk was poured into three containers. Two of the containers were pasteurized at 75ºC for 10 min; one of the containers containing pasteurized milk was labeled PFFM. The fat that settled on top of the other pasteurized milk was scooped

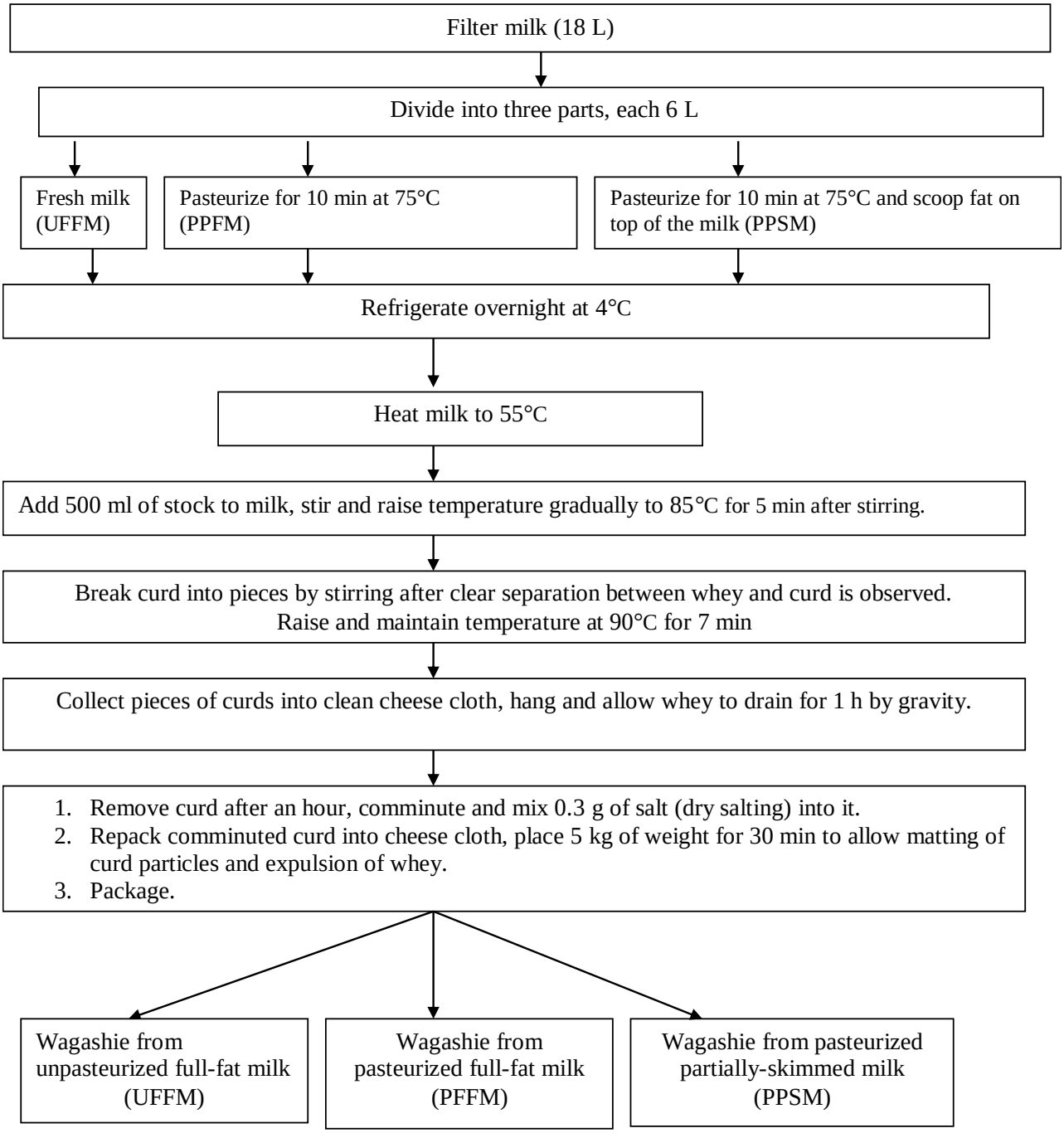

Figure 2. Wagashie preparation step.

partially and labeled PPSM. The unpasteurized milk was labeled UFFM. Together with UFFM milk, PFFM and PPSM milk were kept in a refrigerator (4ºC) overnight for twelve hours.

The preparation step: Milk treatment during the Wagashie preparation step was the same for UFFM, PPSM and PFFM after the twelve hour refrigeration period.

Milk was heated up to a temperature of 55ºC and 500 ml of the stock was added. The milk was stirred and the temperature was gradually raised up to 85ºC, five min after stirring. After a clear separation of whey and curd was visible, stirring was repeated to break the curds into pieces. The temperature was then raised to 90ºC and maintained for seven minutes after stirring. The pieces of curd were collected into cheese cloth and whey drained by gravity for an hour. The mass of curd was comminuted into pieces and 0.3 g of salt added; the salt was mixed well with the comminuted curds. The pieces of curd were repacked into the cheese cloth and 5 kg weight placed on it to allow more whey drainage for 30 min. The matted curd was removed from the cheese cloth and then packaged (Figure 2).

Table 1. Chemical test values from week zero to week four for the four Wagashie types.

Treatment	Storage time	(week)	% Moisture (Wet basis)	% Protein (Wet basis)	% Fat (Wet basis)	% FFA
UFFM	0		47.35± 0.01^{a}	20.63±0.27^{a}	41.14±0.04^{a}	N/A
	1		45.76±0.11^{b}	22.04±0.01^{b}	40.15±0.09^{b}	0.67±0.00^{a}
	2		45.98±0.18^{b}	21.64±0.01^{c}	39.05±0.08^{c}	1.06±0.00^{a}
	4		45.79±0^{b}	21.20±0.01^{d}	39.53±0.23^{d}	1.57±0.26^{b}
PPSM	0		47.76±0.15^{a}	20.63±0.23^{a}	41.00±0.33^{a}	N/A
	1		46.61±0.08^{b}	21.03±0.13^{a}	40.72±0.35^{a}	1.02±0.01^{a}
	2		45.98±0.18^{c}	21.84±0.11^{b}	40.98±0.39^{a}	1.01±0.01^{a}
	4		46.87±0.04^{b}	20.89±0.26^{a}	42.27±0.13^{b}	1.63±0.01^{b}
PFFM	0		48.46±0.01^{a}	19.79±0.27^{a}	43.47±0.14^{a}	N/A
	1		45.76±0.13^{b}	20.51±0.01^{be}	41.07±0.06^{b}	0.67±0.00^{a}
	2		45.47±0.13^{c}	20.08±0.26^{ae}	42.94±0.18^{c}	0.98±0.01^{b}
	4		44.9± 0^{d}	20.16±0.25^{a}	42.51±0.18^{d}	1.03±0.02^{c}
D	0		63.80±0.04^{a}	16.94±0.13^{a}	31.41±0.28^{a}	N/A
	1		51.86±0.09^{b}	20.62±0.11^{be}	32.32±0.02^{b}	1.08±0.22^{a}
	2		47.42±0.05^{c}	21.19±0.26^{b}	36.32±0.30^{c}	0.95±0.18^{a}
	4		50.46±0.10^{d}	20.27±0.41^{ce}	36.63±0.37^{c}	1.90±0.01^{b}

The data represent mean ± standard deviation of two replications. Means within the same parameter for each Wagashie sample without a common superscript differ (P< 0.05) based on LSD. N/A= Not applicable.

Packaging and storage

Wagashie from the four treatments was cut into strips of 5 cm × 2 cm × 2 cm dimension. Each strip was wrapped with cling film (made from low density polyethylene) and then wrapped with aluminium foil of thickness 91.1 µm. Ten strips of each treatment were placed in separate vacuum pouches (high density polyethylene) of thickness 87.5 µm and dimension 17 cm × 17 cm. A total of twelve sets of vacuum pouch (three each for UFFM, PFFM, PPSM and control-D- treatments) were stored for week one, two and four.

Vacuum packaging was done at a pressure of 11.1 bars with Audion Vacuum pack (Audion-Vac VM150H, Netherlands) after which the samples were transferred into the climatic chamber (Binder Climatic Chamber, Germany) for storage.

Climatic chamber temperature and mean humidity were 12ºC and 65% respectively for the entire storage period. One pack of each treatment was randomly picked on the first, second and fourth week for chemical analysis. Before storage was started, chemical analysis was conducted on fresh samples of each treatment; this represented results for week zero.

Chemical tests

The following tests were carried out on week zero, one, two and four: Moisture, crude protein, fat, and pH analysis according to the methods proposed by Association of Official Analytical Chemists (1990), and free fatty acid (FFA) according Kirk and Sawyer (1997).

Statistical analysis

Analysis of variance (ANOVA) on the data and graphical representation of the pH result were carried out using Statistical Package for Social Sciences Windows 16.0 (SPSS) and Excel (2003) respectively. Where variations were observed among the four treatments at 5%, least significant difference (LSD) was carried out to determine the sources of variation.

RESULTS AND DISCUSSION

Table 1 shows the chemical results of the various treatments studied from the beginning of storage to the end.

Moisture

Generally, the percent moisture of all the Wagashie samples decreased significantly (p< 0.05) from week zero to week four (Table 1). The general decrease in moisture content may be attributed to liquid exudation and syneresis from the product into the flexible plastic package. Fermentation by the proliferating lactic acid bacteria may have produced lactic acid (Korkeala and Björkroth, 1997). Lypolysis and proteolysis may have produced free fatty acids and acidic amino acids, respectively, (Dermiki et al., 2007) creating a highly acidic environment for the samples. This condition of low pH leads to syneresis.

The highest moisture change occurred in sample D after the storage period (from 63.8 to 50.46%) and the least change occurred in sample PPSM (from 47.755 to

46.87%). Therefore, it could be said that liquid exudation and syneresis were extensive in sample D than the rest causing higher moisture change after storage.

Comparison of changes in week two and four showed a significant increase in the percent moisture of PPSM and D after the storage period (Table 1). This may be attributed to the transfer of calcium from the curd into the whey collected in the package as the pH of the curd decreased. Alalade and Adeneye (2006) reported a similar observation for 'Wara' sample stored in whey for 87 h, the moisture content was higher after the storage period contributing to its softness.

The general decrease in the percent moisture of the Wagashie samples in the current research agrees with the result of Gonzalez-Fandos et al. (2000) who observed an average decrease in the moisture content of Cremoris cheese stored under different atmospheres. However, the current result does not agree with that of Papaioannou et al. (2006) who observed no significant moisture change in stored vacuum packaged whey cheese studied under 12°C for 17 days. The difference may result from the method of production of the two types of cheese.

Protein

The method used for the measurement of percent crude protein takes into account the total nitrogen containing products in the system. The % crude protein increased from week zero to week one and was significant ($p< 0.05$) for all the Wagashie samples except PPSM (Table 1). Reduction in the moisture content of all the Wagashie samples after the first week of storage may have accounted for the increase in the percent protein. Also, rapid production of free amino acids due to the fermentative activity of the proliferating lactic acid bacteria (Gomez et al., 1989) may have contributed to this observation. Crude protein analysis after week one shows that the change in D sample was highest (from 16.935 to 20.62%). Growth of psychrophilic aerobes may have contributed to this since the preservative ability of the package was lost as a result of whey accumulation.

The percent protein content of treatments PPSM and D increased significantly ($p< 0.05$) and insignificantly ($p> 0.05$), respectively, from week one to week two before finally decreasing significantly ($p< 0.05$) at the end of the storage period (Table 1). Treatment UFFM showed consistent significant decrease ($p<0.05$) from week one to week four. Treatment PFFM also showed a decrease in its percent protein from week one to week four. The decreases observed at some points during the storage time (week two for treatment PFFM, week four for treatments PPSM and D, and week two and four for UFFM) may be due to the fact that proteolytic products within the environment served as nutrients for the increasing microbial population (Lioliou et al., 2001).

The result of Appiah (2000) on Wagashie samples treated with varying concentrations of salt and kept under ambient temperature showed a consistent significant decrease ($p< 0.05$) in their percent crude protein. This may be attributed to the ambient storage condition, in contrast with the vacuum and cold storage condition adopted in the present study, which encouraged the rapid growth of the microbes leading to rapid utilization of the proteolytic products.

The result was also inconsistent with that of Abdalla and Mohamed (2009) who reported a progressive decrease in the protein content of vacuum packaged cheese of Sudan origin stored over a 45-day period at 4°C (from 23.26 ± 0.48 at the beginning to 20.23 ± 1.51 at the end of the storage period). This observation may be due to the fact that *Lactococcus lactis* ssp*. lactis* and *Lactococcus lactic* ssp*. cremoris* were used as starter culture in the preparation of the cheese. Proliferation of these bacteria in addition to the resident lactic acid bacteria may have led to excessive utilization of proteolytic products more than they were produced, hence the decrease in the nitrogen containing compounds in the system. In Wagashie preparation, no starter culture is added, therefore, utilization of the proteolytic products was limited.

Fat

The result in Table 1 shows that the percent fat at the end of the storage period was significantly higher ($p< 0.05$) in treatment PPSM (42.27%) and D (36.63%) than at the beginning of storage (PPSM, 40.995%; D, 31.41%). Treatment UFFM showed consistent and significant decrease ($p< 0.05$) in its percent fat from week zero to week two and increase ($p<0.05$) from week two to four. However, the percent fat of PFFM decreased significantly after week one, increased and decreased significantly after week two and four respectively.

The result shows a general fluctuation in the percent fat over a narrow range (31.41 to 43.47%). Even though significant differences were observed for some treatments, fat breakdown (lypolysis) was minimal due to the packaging technique and the storage temperature (12°C) adopted. The opaque nature of the aluminium foil and the vacuum environment that was created caused exclusion of light and significantly retarded the influx of oxygen. Also, the packaging and storage temperature slowed the proliferation of the microbes.

Papaioannou et al. (2006) observed no significant changes ($p> 0.05$) in fat, moisture and protein content of vacuum packaged whey cheese stored at 12°C for 17 days. Appiah's (2000) results on percent fat showed a consistent decrease, that may be attributed to non-protection of the samples from oxygen and light. Also the storage temperature favoured microbe proliferation resulting in the release of microbial lypolytic enzymes to cause breakdown of fat. Changes that occurred in the

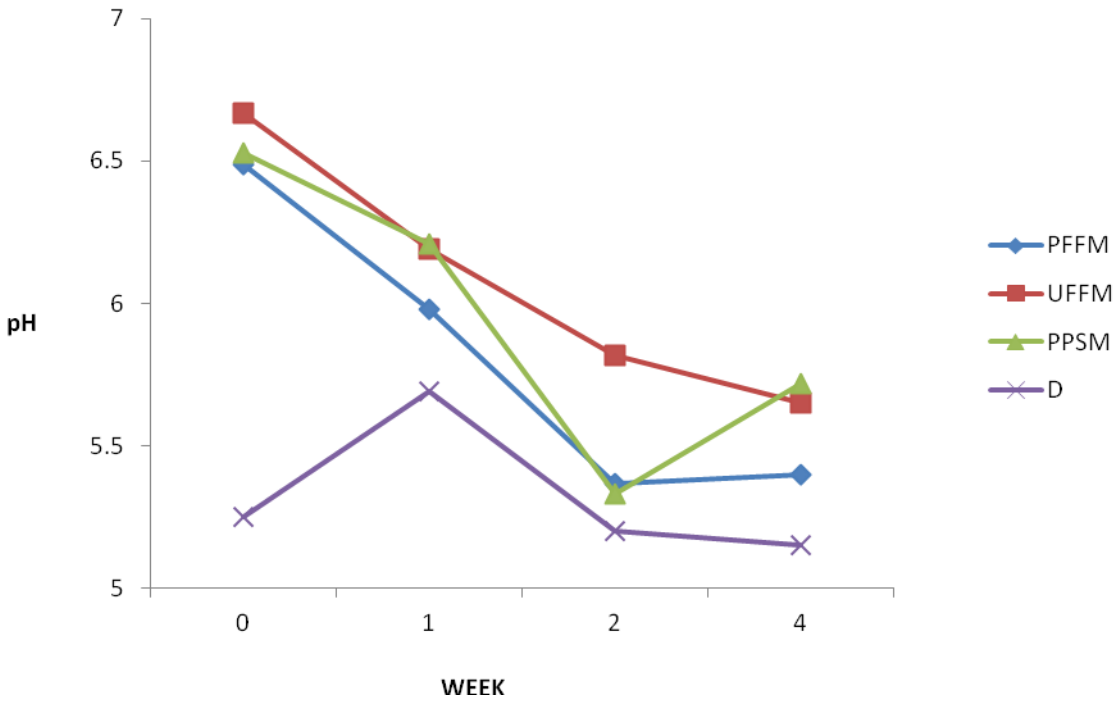

Figure 3. pH trend over the storage period (week 0 to 4).

percent moisture and protein of the Wagashie samples (present study) may have effected the changes observed in the percent fat of the samples.

FFA

The percent free fatty acids of all the Wagashie samples at the end of the storage period showed significant ($p< 0.05$) increase (Table 1). Percent change in FFA of all the Wagashie samples from week one to week two was insignificant ($p> 0.05$) except treatment PFFM which showed a significant ($p< 0.05$) increase. The percent FFA was highest in treatment D (1.9%) and lowest in treatment PFFM (1.025%) after the fourth week even though treatment PFFM had the highest percent fat. The percent free fatty acid ranged from 0.67 to 1.9% for the treatments from week one to the end of the storage period indicating that fat breakdown (lypolysis) was minimal.

The breakdown may be attributed to the lypolytic activity of the proliferating lactic acid bacteria releasing intracellular esterases and lipases (Awad et al., 2007). The loss of preservative capacity of treatment D package may have encouraged the influx of oxygen leading to oxidation. This may have contributed to the relatively high percent FFA recorded in treatment D. Dermiki et al. (2007) observed that the degree of lypolysis of packaged whey cheese under vacuum was lower than those packaged in air for a given sampling day. However, Pintado and Malcata (2000b) found that there were no significant differences in the degree of lipolysis in whey cheeses packaged under various atmospheres.

pH

The pH of all the treatments decreased at the end of the storage period (Figure 3). Treatment UFFM showed a gradual decrease from the beginning to the end of storage. Treatments PFFM and PPSM showed gradual decrease from the beginning to the second week of storage and increased slightly from week two to week four. Treatment D showed an increase in pH after week one and then gradually decreased to the end of the storage period.

The rise in pH at certain periods during storage of treatments PFFM, PPSM and D may be attributed to the production of proteolytic products like non acidic decomposition materials and weaker or less highly dissociated amino acids, and liberation of alkaline products of protein decomposition. The utilization of lactic acid produced by the microbes may have also contributed to the rise in the pH after one week of storage (Webb et al., 1983).

The decrease in the pH of all the treatments at the end of storage may be attributed to the production of acid (Korkeala and Bjo¨rkroth, 1997) specifically acidic amino acids and free fatty acids (Dermiki et al., 2007) by the activities of the proliferating microorganisms. This result

agrees with that of Dermiki et al. (2007) who observed a decrease in the pH of stored vacuum packaged cheese.

The pH range (Figure 3) from the beginning of storage to the end was about one unit (6.67 to 5.20) indicating that the change was minimal. This result agrees with that of Gonzales-Fandos et al. (2000) who observed a slight decrease in the pH of vacuum packaged cheese stored for 28 days. According to Martin-Hernandez et al. (1990), this decrease is characteristic of fresh cheese produced without starter culture.

Conclusion

Significant chemical changes occurred in the vacuum packaged Wagashie samples after four weeks of storage. Comparison of the chemical parameters of the treatments before storage (week zero) and after storage (week four) showed the following:

The percent moisture of all the treatments decreased significantly after storage, treatment D and PPSM recorded the highest and lowest percent change in moisture after the storage period. Percent protein of all the treatments increased significantly after the storage period except PPSM and PFFM that showed no significant change. Percent fat of UFFM and PFFM increased significantly and that of PPSM and D decreased significantly after storage. The percent FFA of all the treatments increased significantly after storage.

Vacuum packaging technique adopted greatly influenced the results observed. Loss of the vacuum packaging capability of treatment D as a result of accumulation of whey led to influx of oxygen into the product resulting in higher percent free fatty acid value at the end of storage.

Pasteurization together with vacuum packaging synergistically retarded microbial growth of treatments PPSM and PFFM as evidenced by insignificant percent protein change between week zero and four.

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