KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY KUMASI

COLLEGE OF SCIENCE

FACULTY OF BIOSCIENCES AND BIOTECHNOLOGY

DEPARTMENT OF BIOCHEMISTRY

SENSORY AND CHEMICAL STABILITY OF VACUUM PACKAGED WAGASHIE

TOHIBU ADDO SULLEY

SEPTEMBER, 2009

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THESIS SUBMITTED TO THE DEPARTMENT OF BIOCHEMISTRY, KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY, KUMASI, IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE OF MASTER OF SCIENCE (M.Sc) IN FOOD SCIENCE AND TECHNOLOGY

TOHIBU ADDO SULLEY

SEPTEMBER, 2009

DECLARATION

I hereby declare that this submission is my own work towards the MSc and that, to the best of my knowledge, it contains no material previously published by another person nor material which has been accepted for the award of any other degree of the University, except where due acknowledgement has been made in the text.

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Head of Dept. Name Signature Date

DEDICATION

This piece of work is dedicated to, firstly, Allah and secondly, to my entire family

ABSTRACT

Wagashie samples from unpasteurized full-fat milk (UFFM), pasteurized partially skimmed milk (PPSM) and pasteurized full-fat milk (PFFM) were prepared and a fourth (control termed as 'D') was purchased from the market. The study was to provide descriptive vocabulary for Wagashie, determine sensory and chemical changes during storage, and to establish relationships between sensory attributes and chemical parameters. Vocabulary was generated by twenty panelists using quantitative descriptive analysis. All the four Wagashie samples were vacuum-packaged and stored for four weeks at 12 ^{o}C. Sensory evaluation was carried out on zero and four week old samples using a line scale of 0 (strong) to 10 (weak). Chemical tests (moisture, crude protein, fat, free fatty acid and pH) were conducted on week zero, one, two and four. In all twenty attributes (eleven for the cooked and nine for fried Wagashie forms) were generated. However, fried Wagashie samples were considered for the rest of the research because preliminary survey showed that Wagashie is mostly consumed in the fried form. The fried Wagashie attributes were golden brown, rough and compact, firm, soggy, chewable and friable, typical of Wagashie aroma and flat taste. Four week old samples compared with zero week old ones showed significant differences ($P < 0.05$) for some attributes and insignificant differences ($P > 0.05$) for other attributes. However, they were all within the same region of the scale (either 1 to 5, or 6 to 10). For attribute flat, week zero old samples compared with their respective four week old samples showed significant differences ($P < 0.05$) and fell within different regions of the line scale except sample PFFM. In terms of chemical tests after the storage period, percentage moisture and FFA reduced and increased ($P < 0.05$) respectively. Protein remained unchanged ($P > 0.05$) in sample PPSM and PFFM but increased ($P < 0.05$) in the other two. Fat increased in PPSM and D but reduced in the other two samples ($P < 0.05$). pH of all the Wagashie samples reduced at the end of storage. Correlation analysis showed that a reduction in the percentage fat increased the friability of UFFM sample. Also, increase in FFA altered the taste of all the samples except PFFM. The study showed that the least and greatest change occurred in PFFM and D respectively after storage.

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CHAPTER 1

1.0 INTRODUCTION

Soft unripened cheese called 'Wagashie' is an indigenous cheese known in Ghana. The origin of Wagashie is traced back to the times when Fulani herdsmen convert left-over milk to curd (Ogundiwin, 1978) by coagulating the protein with the liquid extract of the common weed, Sodom Apple (*Calotropis procera*) (Ashaye *et al*., 2006). Others produced Wagashie or Wara by storing milk in the abomasums of slaughtered calves (Sanni *et al*., 1999). This was in order to preserve excess milk. The conversion to a relatively stable form became necessary because of poor transportation network that made getting the milk onto the market on time difficult, and also because of lack of storage facilities to preserve milk that failed to get to the market (Belewu *et al*., 2005).

In traditional making of Wagashie cheese, the juice extract from Sodom apple is added to warmed milk (Ogundiwin and Oke, 1983). The milk is stirred gently 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. The terminology with which this product is called has seen some variations; it is called Woagachi (O' Connor, 1993) and Wara or Warankashi (Ogundiwin, 1978) by the people of Benin Republic and Nigeria respectively.

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 for 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 garlic (Belewu *et al*., 2005) resulted in similar outcomes. However, these chemical additives change the taste of the Wagashie. 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). 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.

Vacuum packaging has been applied to a variety of food products such as meat, cheese, soups etc: Santos *et al*. (2005) observed that vacuum packaged blood sausage stored at 4º C lasted for 22 days while the type stored under air lasted for 17 days. Also, vacuum packaging was able to prolong the keeping quality of ready-to-eat foods with minimal changes for 29 days (Murcia *et al*., 2003).

1.1 Justification

The handling of Wagashie by retailers is not hygienic; retailers hand pick Wagashie curds into polyethylene bags for consumers (Personal observation), making the product highly susceptible to contamination, and predisposing consumers to food-borne diseases. Therefore, vacuum packaging will facilitate the retail of the product without physical contact with it thus reducing the risk of post-package contamination.

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). Therefore, vacuum packaging provides a 'preservative free' method of product storage thus extending the keeping quality of Wagashie.

1.2 *General objective:*

To extend the shelf-life of vacuum packaged Wagashie.

1.3 *Specific objective:*

1. To generate descriptive vocabulary that would characterize the sensory properties of Wagashie.
2. To determine the chemical and sensory changes of four vacuum-packaged Wagashie over a four week storage period, and establish relationship between their chemical and sensory properties.

CHAPTER 2

2.0 LITERATURE REVIEW

2.1.0 MILK

2.1.1 Definition and Selection of Milk

Milk has been defined by the United States Department of Agriculture (2005) as "the lacteal secretion practically free from colostrum obtained by the complete milking of one or more healthy cows''.

In the production of cheese, milk of animal origin is an indispensable raw material. According to Akam *et al*. (1989) the animal from which the milking is done must be in a very healthy condition, the udder carefully disinfected before milking, the surrounding clean and the utensils uncontaminated. In selecting milk for cheese production Le Jaouen (1987) suggested that the milk should have the following properties: It must be free of any visible impurities; it must not have any abnormal taste or odour; the pH must be 6.6 or only slightly higher at the milking time; the milk must not be contaminated by pathogenic microorganisms which may prove undesirable for the production of cheese; and the milk must contain no foreign substances such as antibiotics, antiseptics and cleaning products.

2.1.2 Milk clotting agents

Coagulating agents for cheese production have been drawn from many avenues, namely animal, plant or bacterial and fungal sources. Lactic curd cheese type is produced when milk is allowed to ferment naturally without the addition of bacterial cultures or materials that will cause coagulation of the milk. Whey separation then follows after the coagulation. These naturally fermented milk provided the first available `starter' culture to be used for the precipitation of the protein (casein) with other milk constituents such as fat, lactose (milk sugar) and vitamins (O'Connor, 1993).

With advancement in biotechnology and microbiology it has become possible to obtain coagulating agents from engineered bacteria and fungi. The gene for chymosin was cloned and inserted into microorganisms such as *Kluyveromyces marxianus* var. *lactis*, *Aspergillus niger* var. *awamori* or *Escherichia coli* which led to the development of recombinant chymosins which are now marketed commercially (Sousa *et al*., 2001). Chymosin (a naturally clotting enzyme) has been used extensively and has, probably, been reliable for many varieties of cheese. It is rennet extracted from the stomach of a mammal specifically the fourth stomach (abomasums) of calves (O'Connor, 1993). In the past, Wagashie was prepared by people by storing milk in the abomasa of slaughtered calves where the enzyme rennin resides (Sanni *et al*., 1999).

Acids have also been used for many years to cause the coagulation of milk for cheese production. The use of acids such as acetic acid, citric acid, lactic acid, vinegar and lemon juice for milk coagulation have been documented (O'Connor, 1993). For example, Ricotta cheese (a variety common in Italy), made from a mixture of skim milk and whey, uses vinegar or citric acid to precipitate the casein leading to the formation of curd. Another cheese of Italian origin, Mozzarella, which is used as a topping for pizzas, is made with lactic or acetic acids as acidulants.

Juice extracts from fruits and plants have long been used as milk clotting agents. The proteases present in the juices and those naturally present in milk are believed to play a role in the impartation of aroma and texture to cheeses (Visser, 1977; Adler Nissen, 1993).

Examples of plants with such properties are papaya (papain), pineapple (bromelain), castor oil seeds, latex from fig tree and Sodom apple (*Calotropis procera)* plant, which grow abundantly in Africa (O'Connor, 1993).

Sodom apple is a plant that is described as soft wooded, evergreen, perenniel shrub that oozes a copious amount of white sap when bruised at the stem or leaf (Parrota, 2001). The juice extract is an alternative to the use of rennin from the stomach of calves since it contains a similar protease enzyme called Calotropin (Dalziel, 1948). According to O' Connor (1993), although it has been perceived by people that the juice extract contains toxic substances, there is no evidence to support this assertion since consumers are not adversely affected after consumption of Wagashie. It appears that toxins in the Sodom apple juice extract are destroyed by the high temperatures (95°C) to which the milk is heated during the cheese preparation. He also stated that the juice extracts are suitable for softer curd cheeses which are consumed within few weeks.

Wagashie is not a fermented milk product and as such, the proteinase enzyme employed does not need a very acidic medium, it is active at neutral pH (Ashaye *et al*., 2006). During the extraction of the enzyme, the leaves are crushed and water added, this mixture is allowed to stand for about twenty minutes after which the chaff is separated from the liquid portion; the enzyme activity is associated with the supernatant rather than the sediments (Ogundiwin, 1978).

This process of cheese making suggests that the protease in Sodom apple juice extract is active at high temperatures. This assumption is supported by a research carried out by Raheem *et al*. (2006) when the juice extract was tested for rennet activity over a temperature range of 35 ºC and 70 ºC, and compared with the activities of the standard chymosin rennet. The temperature effect on the rennet activity was determined according to a method proposed by Zotos and Taylor (1997). The reaction mixture developed was made up of 2.5 ml of 0.5% (w/v) casein in phosphate buffer of pH 7.0 and 0.3 ml of enzyme solution. The temperature effect on the protease activity was determined by incubating the reaction mixture at different temperatures (20–100°C) in a water bath for 2 min. The results showed that at temperature of 35°C (that is the temperature at which calf rennet causes coagulation), the rennet strength of Sodom apple rennet was 6.9% of the standard (that is if the standard is 10000). However, at elevated temperature of 70°C, nearly twice the rennet strength of the standard was recorded for Sodom apple rennet. In other words, an increase of about 28 times was recorded from a temperature of 35 to 70°C. This shows that the rennet from Sodom apple has not only got strong activity at higher temperatures (close to that of traditional Wagashie cheese making) but also enzyme activity higher than that of standard calf rennet. The optimum temperature and pH for optimal rennet activity was found to be 75ºC and 5.6 respectively. Additionally, it was determined from this research that the specific activity of the enzyme, in which a unit is defined as the activity which produces an increase of 0.001 absorbance unit at 280 nm per minute (Arnon, 1970; Liu *et al*., 1999), increased from 0.107 in the crude coagulant to 2.933 units per milligram protein in the purified coagulant.

Sodom apple extract shares optimum rennet activity with some plant extracts. Proteases from crude plant extract of snakegourd – *Trichosantus kirilowi* (Uchikoba *et al*., 1990), *Trichosantus cucumeroides* (Kaneda *et al*., 1986), dandelion roots (*Benincasa cerifera*) (Bogacheva *et al*., 1999) and persianmelon (*Cucumis melo*) (Kaneda and Tominago, 1975) all show optimal activity of about 70°C. However, Chymosin from both microbial and animal sources which is commonly employed in cheese making has lower thermal stability of 35°C and optimal pH range between 2 and 4 (Raheem *et al*., 2006).

The juice extract of Sodom apple is not suitable for hard cheese with long maturing periods on account of their excessive proteolytic activity which leads to bitter aroma in the ripened cheese (O'Connor 1993). This has been supported by Guinee and Wilkinson (1992) who said that the use of heat stable coagulants other than calf rennet should be avoided since the residual rennet will result in excessive proteolysis and bitterness as a consequence of its high proteolytic activity. They said this can be mitigated if ripening times and /or cooking temperatures are changed to compensate for the more rapid rate of proteolysis.

2.2.0 CHEESE

2.2.1 *Definition of cheese*

The German cheese-making regulations regard cheese as "fresh products or products at varying degrees of ripeness which are made from coagulated cheese-making milk" (www.tis-gdv.de).

There is no one definite way of classifying cheese since it has been classified differently based on several factors; cheese may be classified according to their water content.

The Table below shows the description of different types of cheese based on water content of the fat free solid and fat in dry matter.

Table 2.0: Classification of Cheese based on Water Content of the Fat-Free solid and Fat in Dry matter

Cheese type	Water in fat free substrate (%)	Fat in dry matter (%)	Description class (%)
Extra Hard	< 51	> 60	High fat cheese
Hard	49 – 55	≥45 – 60	Whole milk cheese
Half fat	53 - 63	≥ 25 - <45	Half fat cheese
Semi-soft	61- 68	>10 - <25	Low fat cheese
Soft	> 61	<10	Skimmed milk cheese

(Source: FAO/WHO, 1973).

A variety of cheeses have been reported in literature, this variation, principally, is due to the geographical location where the product is produced (www.dairyforall.com). In Europe alone there are over a hundred varieties- Lancashire cheeses, cheddar, Cheshire from U.K; Roquefort, Neufchatel from France; Romadur, Munster from Germany etc- Cottage cream, Cheddar swiss are common in the United States. In West Africa, so far, only one indigenous soft unripened variety is known and that is Wagashie.

2.3.0 Review of Wagashie production in West Africa

2.3.1 *Historical background and geographical distribution*

Wagashie has been described as soft white unripened cheese by Ogundiwin (1978); it has also been described as soft, wet, feta-like cottage cheese made from whole milk by Jansen (1990). Sometimes it is sold fresh, but more often in the fried form (Jansen, 1990).

Wagashie consumption is not limited to only one West African country but has spread throughout out the sub region due to the nomadic character of Fulani's. It appears that its preparation and consumption is mostly prevalent in areas where assess to fresh milk is easy. Its patronage is mostly prevalent in the Northern (Jansen, 1990) and South Western parts of Nigeria (Jabbar and Domenico, 1990), Northern Province of Benin Republic (O'Connor 1993) and Northern part of Ghana.

2.3.2 Preparation and Composition

In Wagashie production, milk from cow is used. About five liters of fresh milk is needed to produce about 1kg of Wagashie when Sodom apple is used as a coagulant and also depending on the extent to which the whey is drained off (Otchoun *et al*., 1991; Egounlety *et al*., 1994). This implies that for Wagashie to be produced on a commercial scale, sufficient amount of milk is needed.

Till now the processing method across the countries where this cheese is consumed has generally remained the same even though there are significant and interesting variations; Woagachi is larger (about 600g) than Wara or Wagashie (about 60g). The difference in size stems from the raffia molded basket that is used. Usually, Woagachi cheese is coloured in a red hot solution of sorghum by dipping the product in the solution for some few seconds, this process is preceded by immersion in salt solution for few hours (O'Connor, 1993). Some producers of Wara or Wagashie during the preparation, may prefer to add salt to taste and not to act as a preservative, additionally, the product is sold uncoloured (Public opinion).

When freshly prepared, Wagashie has a moisture content ranging from 50-60% depending on the extent of whey drainage, and pH range of about 6-6.5. The composition of Wagashie shows about 4-7 times increase in protein content (13%), fat (16%) and about 20 fold decrease in lactose relative to the original fresh milk (Ihekoroye and Ngoddy, 1985). Wagashie shares some similarities with cottage cheese in that, they both have high amount of moisture that ranges from 50-60% placing them in the category of soft cheese. They also have curd-like texture and do not go through the ripening stage of cheese-making. The difference between these two types of cheese is that where as cottage is prepared with starter culture, typical Wagashie is not inoculated prior to preparation (Ashaye *et al*., 2006).

2.3.3 Quality Improvement of Wagashie

Studies by Appiah, (2000) and Ashaye *et al*. (2006) on Wagashie have shown that this product deteriorates within two to three days when stored in its whey under ambient condition after production. Producers of Wagashie, traditionally, preserve them by boiling in water or salt solution. Others achieve similar results by frying, smoking or drying (Personal observation).

Studies on the use of chemical preservatives and plant extracts have been employed, because of their antimicrobial properties, to achieve the feat of shelf-life extension. In a research conducted by Belewu *et al*. (2005) biological extracts (ginger, garlic and sorghum) and chemical preservatives (0.8% propionic acid and 0.8% benzoic acid) were compared with ordinary boiling to determine their effect on proximate composition of Wagashie over a fifteen day period. No significant difference ($P > 0.05$) was reported on the proximate composition changes except crude protein. The samples treated with garlic and ginger extracts recorded increases in their crude protein values whereas the rest recorded decreases in their crude protein values. The shelf-life of the chemically treated samples was nine days, while the sorghum extract treated and the boiled ones had a shelf-life of four days. These results agree with a similar research conducted by Joseph and Akinyosoye (1997).

In a related experiment carried out by Appiah, (2000) on Wagashie samples subjected to repeated boiling in water and different concentrations of NaCl solution, the results showed that NaCl treated samples had superior qualities over the boiled ones. The salt treated samples lasted up to the twentieth day and the boiled ones lasted for seven days. Millet stalk, which is perceived by many producers of Wagashie in Ghana to have some antimicrobial activity, was shown to show no activity against bacteria (Appiah, 2000).

Improvement of the quality of Wagashie or Wara other than the shelf-life has been studied by Sanni *et al*. (1999). In his study, aroma, texture and nutritional profile were enhanced by the introduction of starter culture; *Lactococcus lactis* was found to be the most suitable lactic acid bacteria among ten others screened from abomasum sour milk. The screening was based on the ability to produce lactic acid, diacetyl, β-galactosidase and an average weighted firm curd at 30 °C after six hours. Overall, the new Wara sample was superior over the traditional type: Wara produced by this procedure showed a 54% increase in protein, 17.9% increase in ash, 23.6% increase in iron and a 150% increase in vitamin A content. However, consumers showed preference for Wara prepared in the traditional way in terms of appearance and texture but liked the aroma and palatability of the 'improved' type.

2.3.4 Spoilage Causing Microbes of Wagashie

In view of the near neutral pH of Wagashie (about 6.0), moisture (about 50%) and low salt content, and rich nutritional composition when freshly prepared, this product is highly susceptible to microbial attack. Appiah, (2000) in his research observed that beyond three days of storage of Wagashie under ambient condition a pungent, rotten-like smell evolves with development of slimy texture and appearance of maggots. According to Papaioannou *et al*. (2006), fresh whey cheeses have high pH (>6.0), high moisture content and a low salt content, because of this they are very susceptible to microbial spoilage by moulds, yeasts, and *Enterobacteriaceae*, especially under 'abuse' temperatures. Storage of fresh whey cheeses under aerobic condition results in rapid spoilage, usually in less than 7 days. In the light of the similarities shared between these cheeses it could be said that spoilage of Wagashie is caused by these microorganisms under ambient temperature.

2.3.5 Safety of Wagashie Production

In Ghana many of the Wagashie production sites are unkempt, most of the people involved in Wagashie production do not uphold good hygienic practices. This leads to both pre and post contamination of the cheese. Also, the source of milk, the milking process and the site of production are questionable from the standpoint of hygiene (Personal observation).

According to Fox *et al*. (1996); Muehlenkamp-Ulate and Warthesen (1999); and Sousa *et al*. (2001), lack of adherence to hygienic principles in production line leads to contamination of cheese with non-starter lactic acid and psychotrophic bacteria. These organisms dominate the ripening of cheese with their proteolytic and/or lipolytic activities, and secondary metabolism. In view of this, sometimes the process becomes unpredictable or uncontrollable and nonspecific cheese texture and flavours such as bitterness may occur. Wagashie production, therefore, must be carried out in an environment that is in good sanitary condition. Cattle from which the milk is obtained and the milking process must be done in the light of strict adherence to hygiene. For this to be possible effort must be made to educate producers on how to maintain good sanitary conditions and the need to do that.

2.4.0 CHANGES IN CHEESE COMPOSITION DURING RIPENING

During storage of cheese biochemical changes such as glycolysis, proteolysis and lypolysis take place changing the composition of the cheese, these changes impart characteristic features to the cheese especially the texture and flavour.

2.4.1 *Proteolysis*

Proteolysis plays a very important role in the development of texture and flavour in cheese during ripening. In milk Cathepsin D and Plasmin are the major enzymes that cause proteolysis; Cathepsin D is active at temperature and pH of 37ºC and 4.0 respectively (Kaminogawa and Yamauchi, 1972; Barrett, 1972), while Plasmine is active at 53ºC - 55ºC temperature range (Richardson and Pearce, 1981). Other sources of proteolytic enzymes are residual coagulant in cheese, and starter and non-starter microbes. In causing textural changes to cheese matrix proteolysis leads to the breakdown of protein network, decrease in water activity through water binding with liberated carboxyl and amino groups and increase in pH (in particular in surface mould-ripened varieties). As a result, the flavour of the cheese is affected, these changes if not controlled during ripening may lead to the production of a defective cheese. An example of a defect in cheese is the development of off-flavour, specifically bitterness. Bitterness in cheese is often due to the production and accumulation of hydrophobic peptides by the action of coagulant and starter proteinases. The accumulation of these peptides to excessive concentration may be due to either over production or inadequate degradation by microbes.

2.4.2 *Lypolysis*

Lypolysis is the hydrolysis of triglycerides to produce free fatty acids (Fox *et al.*, 1993). Production of free fatty acids (FFA) due to the degradation of lipids is mainly caused by lipase of milk origin. Lipase action is high in raw milk compared to pasteurized milk. According to Vlaemynck (1992), pasteurization of milk partially inactivates milk lipase, Driessen (1989) stated that heating milk (pasteurization) at 72^{o}C for 10s completely inactivates milk lipase. High salt concentration also is inhibitory to milk lipase. This indigenous milk enzyme has optimal activity at pH value of 8.0-9.0 and temperature of 35 to 40^{o}C. FFA can be produced from the metabolism of carbohydrates and amino acids by bacteria (Urbach, 1993; Fox and Wallace, 1997). The lipolytic activity of the lactic acid bacteria is very limited and is mainly on mono-and diglycerides formed by the action of milk LPL (Stadhouders and Veringa, 1973). Most of the lipolytic enzymes of the lactic acid bacteria show their maximum activity at pH values close to neutral. According to Downey (1980), the combination of low pH (4.75) and high salt content (2%) during ripening, is inhibitory to lipolysis related to microbial growth.

2.4.3 FFA

Free fatty acids (FFAs) contribute to cheese flavour and serve as precursors for a variety of other compounds such as alcohols, esters, aldehydes, ketones and lactones (Langsrud and Reinbold, 1973; Urbach, 1993; Molimard and Spinnler, 1996; Fox and Wallace, 1997). FFA's are the major contributors to the development of the characteristic flavour in some cheese varieties, e.g. hard Italian and blue type cheeses (Fenelon and Guinee, 2000). However, extensive lipolysis is considered to be undesirable for some cheeses (Fox *et al*., 1995). Cheeses such as Cheddar, Gouda and Swiss-type that contained even a moderate level of FFA would be considered rancid. FFAs undergo rapid rancidity when attacked by oxygen during storage (www.ag.auburn.edu).

2.4.4 *pH*

Reduction in the pH of cheeses during ripening may be attributed to the continued production of lactic acid by live cells of lactic acid bacteria (Korkeala and Bjo¨rkroth, 1997) and or the liberation of certain amino acids (such as aspartic and glutamic acids) during proteolysis (Sallami *et al*., 2004; Trepanier *et al*., 1992). Also lypolysis may contribute to increased acidity of a cheese system due to the production of free fatty acids (Dermiki *et al*., 2007). Reduction in the pH of a cheese system causes syneresis (loss of moisture) in the cheese. In some cases during ripening the pH of the cheese may increase, this may be due to the combined effects of the utilization of lactic acid, formation of non- acidic decomposition products and weaker or less highly dissociated amino acids. The liberation of alkaline products from protein decomposition also contributes to pH increase of cheese (Webb *et al*., 1983).

In a research conducted by Alalade and Adeneye (2006) on Wara samples stored in whey for 87 hours at room temperature, they observed a consistent increase in the percentage protein and a general increase in the moisture content of the samples. They attributed the rise in the protein content to the increased fermentative activity of the proliferation lactic acid bacteria. The general increase in the moisture content was attributed to the transfer of calcium from the curd into the whey as the pH of the curd and the whey decreased. However, at the end of the storage period these changes were not significant.

2.5.0 SPOILAGE OF CHEESE

Cheese is not only an excellent diet for humans but also for many microorganisms. Cheese spoilage is brought about by microbes such as bacteria (Weber and Broich, 1986), moulds (Lund *et al*., 1995) and yeasts (Westall and Filtenborg, 1998); the growth of these microbes change the chemical composition of the cheese.

2.5.1 *Mould*

Mould growth can be observed on cheese during ripening, storage at the factory or during retail distribution. Spoilage on cheese becomes visible due to the appearance of mould colonies on the cheese surface and the off-aroma that accompany's it. Only a few number of mould species are capable of causing cheese spoilage. These species are well adapted to the relatively high fat and low pH environment of many cheese types (Hocking, 1997). Some species are also capable of growing in an atmosphere with high levels of carbon dioxide (Haasum and Nielsen, 1998) and show resistance to weak acid preservatives (Filtenborg *et al*., 1996). An example is species belonging to the genus *Penicillium*- specifically *P. roqueforti*. Also, some species of *Penicillium* are able to withstand low temperatures and cause spoilage of cheeses kept at that condition; *P. solitum* is an example which was isolated in spoiled cheeses retrieved from a refrigerator in a research conducted by Lund *et al*. (1995).

2.5.2 *Yeast*

Yeasts have been implicated in the spoilage of a variety of cheeses. The activity of yeasts is noticed when swelling of the package containing the cheese is evident. Vivier *et al*. (1994) found *Candida sphaerica* (anamorph of *K. lactis*) to be associated with swelling of cans containing feta cheese. This swelling occurs when the concentration of the yeast exceeds about 10^4 CFU g^{-1}; for instance, *Dekkera Anomala* was implicated in causing swelling of the cans of a Sardinian feta cheese when the yeast count reached about 10^6 CFU g^{-1} (Fadda *et al*., 2001). Feta cheese, which is a soft white cheese made from unpasteurized sheep's or goat's milk, is a popular traditional Greek cheese. It is also produced in a popular ewe milk producing region in Italy called Sardinia.

Many studies on yeasts occurrence in feta cheese have been made. According to Kaminarides and Laskos (1992), the dominant yeasts from brine Greek feta cheese were *Saccharomyces cerevisiae*, *Candida famata*, *Torulaspora delbrueckii* and *Pichia membranaefaciens*. Westall and Filtenborg (1998) reported *T. delbrueckii*, *Debaryomyces hansenii*, *C. sake* and *Kluyveromyces marxianus* as the dominant yeasts from feta cheeses obtained from three different Danish dairies made from pasteurized cow's milk. In Sardinian feta cheese, *Debaryomyces hansenii*, *Kluyveromyces lactis*, *Dekkera anomala*, *Geotrichum candidum* and *Dek. Bruxellensis* were the dominant ones (Fadda *et al*., 2001).

2.5.3 *Bacteria*

Psychrotrophic bacteria have been implicated in the spoilage of a variety of cheeses; one such cheese is cottage cheese. Stone *et al*. (1967) and Rosenberg *et al*. (1994) have reported that the shelf-life of cottage cheese is less than two weeks and this has brought about economic loss to processors and has discouraged repeated purchase of such cheeses by consumers. The short life span of cottage cheese, which is between 1 and 2 weeks stems from post-contamination of the product by psychotrophic bacteria (Weber and Broich, 1986) since microbes that cause spoilage of this kind of cheese are heat sensitive and therefore do not survive the cooking process during preparation (Bigalke, 1985). The growth of these organisms in cottage cheese cause sliminess, bitterness, off-aroma, and color defects and this invariably leads to spoilage.

2.6.0 PRESERVATION OF CHEESE

Several preservation methods have been proposed for maintaining the life of a variety of cheeses. A few of them are freezing, brining and boiling, use of chemical preservatives and modified atmosphere packaging.

2.6.1 *Freezing*

Freezing of cheese curd has been considered, traditionally, as the most suitable alternative for regulating the cheese market (Veisseyre, 1980). To preserve aroma and key physical properties of unripened cheeses such as Mozzarella, cottage cheese, and cheese curds freezing is one of the methods to use (Desrosier and Tressler, 1977; Fennema, 1972; Luck, 1977). According to Luck (1977), frozen storage was suitable for cream cheese, unripened Camembert, and Brick cheese, but not for Gouda or Cheddar cheese. Cervantes *et al*. (1983)

concluded that freezing (one-week storage) and thawing did not affect the quality of mozzarella cheese as assessed by compression, beam bending and sensory evaluation.

Research on the effect of freezing rates and frozen storage duration on the sensory (Tejada *et al*., 2000), chemical and microbiological characteristics (Tejada *et al*., 2002) of ripened Los Pedroches cheese (a home-made Spanish semihard cheese) showed that this cheese could be stored at −20°C for approximately 6 months without any significant alteration of the characteristics studied. However, freezing of dairy products (including cheese) has been generally avoided due to the tendency towards physical breakdown in body and structural characteristics caused by ice crystal formation (Webb and Arbuckle, 1977). The freezing process includes freezing, frozen storage and thawing. These processes may lead to protein and fat destabilisation (Lück, 1977) and also affects microorganisms (Fennema *et al*., 1973). In addition, several transformations may occur during maturation when cheeses are frozen prior to ripening. One of such transformation is protein breakdown which is the most significant event that takes place during ripening of most cheese varieties (Law, 1987). Therefore, Wagashie would be better stored with a preservative method other than freezing.

2.6.2 *Brining and Boiling*

Cheeses have been preserved, traditionally, by boiling and keeping the boiled cheese in its whey. In other situations, cheeses have been either cold or hot brined. For instance, Nabulsi cheese, a salted cheese of Jordanian origin, is boiled in about 18-20% salt solution and then stored in cans without refrigeration. Boiling of the Nabulsi cheese was found to be similar to milk pasteurization in the context of the boiling effect on microbial flora of the milk. In addition to boiling, preservation of Nabulsi cheese was further enhanced, by two factors:

high salt concentration and tight closure of cans. Increasing the salt concentration of a highly salted cheese like Nabulsi by placing the samples in cans with salt concentration range of 12.2-26 is a potent way of greatly inhibiting the growth of spoilage bacteria that are salt intolerant (Yamani *et al*., 1987). The tight closure of the can would prevent external contaminants from coming into contact with the product and also to a greater extent cut off oxygen infiltration into the surrounding of the product thereby restricting the growth of salt tolerant spoilage aerobes.

However, high salt treatment of food products imparts salty taste to the product. Also, people are becoming increasingly careful about high salt intake since excessive intake has been linked to many medical problems such as hypertension, exercise-induced asthma, heart-burn, osteoporosis, left ventricular hypertrophy etc (www.en.wikipedia.org).

2.6.3 *Chemical Preservation*

Some successes have been made in the use of chemicals to preserve cheeses. Aly, (1996) conducted a study on the use of potassium sorbate to extend the shelf-life of Mozzarella cheese. The results showed that the keeping quality of the potassium sorbate treated samples were superior over the untreated control (sorbate treated samples lasted for about 10 weeks while control lasted for only 4 weeks).

Attempts have been made to control mould growth on cheese surfaces by impregnating the wrapping or packaging material with fungicides or fungistatic chemicals. Using natamycin to prevent surface moulding in cheese is a common method, it has been classified as preservative, mould preventive, and antibiotic (Robinson, 1990).

However, chemical preservatives like Sodium benzoate, ascorbate, propionate etc have been linked to many health problems such as allergies, and are believed to cause serious illness such as initiation of carcinogenesis (Halliwell *et al.*, 1995). Therefore, the use of a 'preservative free' packaging technology to maintain the quality of food product for a considerable long period of time will be a good alternative.

2.6.4 *Preservative Packaging*

Packaging has been defined in many ways, but the fundamental definition of packaging is to contain, protect, preserve and inform. Two more functions performed by a package are they provide convenience and aid in selling (www.packaging-guide-to.com).

Growth of spoilage microorganisms limits the storage life of food and food products. The principal function of preservative packagings is to retard spoilage by restricting the growth of spoilage organisms, and spoilage of non-microbial origin (Gill and Molin, 1991). Combination of flexible packaging and modified atmosphere packaging technology provides a 'preservative free' way of considerably extending shelf-life of fresh and processed foods. In modified atmosphere packaging (MAP), film properties (permeability and transparency) greatly affect the chemical and the physical properties of products.

Preservative packagings come in different forms- rigid and flexible- and are made from plastic, paper or metallic materials or a combination of more than one of these materials. Examples of substrates (materials) from which flexible packagings are made from are polyethylene, polypropylene, polyvinylchloride, polyamide, cellophane, polyester, and aluminum foil. These substrates have properties that are advantageous or disadvantageous depending on the product being packaged. For instance, polyethylene has low permeability to water, high permeability to gas, and absorbs oil and grease. It has low tensile strength, elongates easily and is most commonly used in combination with other substrates. Depending on the density, polyethylene may be classified as low, medium or high density. Aluminum foil exhibits good resistance to gases, oil, heat, and corrosion. Its reflective property makes it an attractive packaging; it is also light in weight, non-toxic, and opaque (Davies, 1991).

Packing of foods in transparent materials greatly increases the risk of light-induced oxidation. Milk and milk products are particularly sensitive to light, and the photo-initiated reactions affect not only the sensory quality but may also lead, some times, to the formation of toxic compounds and degradation of nutrients (Sattar and deMan, 1975). The best way to protect dairy products is to exclude all kinds of light exposure (Borlet *et al*., 2001). The use of metallized films like aluminium foil can be very effective (Buguen˜o *et al*., 2003) in this situation.

More than one packaging material has been used to preserve food products. Davies, (1991) reported that one material does not have all the properties necessary to preserve the quality of a food product, a combination of two or more materials may have the necessary properties to sufficiently preserve the keeping quality of food under modified atmosphere. This is because of the synergy that is created by the combination and this appreciably preserves the product compared to preservation by only one material type.

2.6.4.1 ***Modified Atmosphere Packaging Technology***

Changes in the packaging atmosphere (aerobic, vacuum or modified atmosphere) are used in the food industry to extend products shelf-life (Ferna´ndez-Lo´pez *et al*., 2008). To achieve the purpose of shelf-life extension, Davies (1991), said that the various gaseous components of the natural atmosphere must be altered and then introduced into the pack holding the product to be stored. This technology takes advantage of the gas requirements of microbes. The presence of microbes in an altered gaseous environment limits their growth.

He identified three types of modified atmosphere packaging:

1. Modified Atmosphere Packaging (MAP)

The gas within the pack holding the product is replaced with a fixed mixture of gases and no further control is exercised during storage. This technology is suitable for storing retail products.

2. Controlled-atmosphere packaging (CAP)

The gas composition within the pack is controlled to provide optimal condition throughout the storage period. This is applied to bulk storage of products.

3. Vacuum packaging (VP)

The original air within the pack is evacuated and the pack sealed creating a vacuum around the product. With time, "the gaseous atmosphere of the vacuum package is likely to change during storage (from metabolism of the product or microorganisms) and therefore the atmosphere becomes indirectly modified".

Vacuum packaging has so far been the most widely used packaging technique for cooked products (Borch *et al*., 1996, Korkeala *et al*., 1985 and Samelis *et al*., 2000). Modified atmosphere packaging technology has been applied extensively in the storage of meat and poultry products: Ranking (1987), in his study of meat under storage found that vacuum packaging (or controlled atmosphere packaging) produced a satisfactory result in preventing rancidity and colour problems. A study of the microbiological quality of poultry under vacuum packaging by Warszawa, (1997) showed that aerobic microorganisms, proteolytic bacteria, yeasts and moulds were all inhibited. However, the fast spoilage of the poultry was associated with activities of anaerobic, non-spore forming bacteria which are normally associated with raw materials. He, therefore, concluded that the microbiological quality of the packaged product depends on technology of production and microbiological quality of raw materials.

Perishable products have exhibited superior quality under vacuum or MAP storage than under air. A study was conducted by Santos *et al*. (2005) on the microbiological and sensory quality of "Morcilla de Burgos", a blood sausage of Spain origin, under air (without packaging), vacuum and modified atmosphere packaging at 4º C. All groups of microbes (total viable count, psychrotrophs, lactic acid bacteria (LAB), pseudomonads, enterobacteria, moulds and yeasts, enterococci, *Staphylococcus aureus*) analyzed increased in air stored samples. pH of the vacuum and MAP samples decreased (pH 4.73) while LAB became dominant. Sensory analysis showed that shelf-life of ''morcilla'' stored in air did not exceed 17 days, while samples packed under vacuum and MAP were acceptable until 22 days of storage.

Murcia *et al*. (2003) reported that the proximate composition (moisture, proteins, lipids and ash) of cooked 'ready to eat' foods did not change much in vacuum or modified atmosphere packaging compared with conventionally packaged (in air) foods. Vacuum and modified atmosphere packaging were effective for prolonging the shelf-life of the studied products up to 29 days with minimal changes in the proximate composition. This fact has been supported by Papaioannou *et al*. (2006) in a study conducted on shelf-life of Greek Whey cheese under MAP; changes in moisture, protein, fat, and salt content, of samples packaged in VP or MAP showed no significant (P> 0.05) effect at 4º C . Also a report on Anthotyros cheese from retail shops (Kalogridou-Vassiliadou *et al*., 1994) and in vacuum packages stored for 42 days under refrigeration (Tsiotsias *et al*., 2002) agreed with the findings of Papaioannou *et al*. (2006).

2.7.0 SENSORY EVALUATION

Sensory evaluation has been defined by the Institute of Food Technology, USA, (1981) as "a scientific discipline used to evoke, measure, analyze and interpret reactions to those characteristics of food and materials as they are perceived by the senses of sight, smell, taste, touch and hearing" (www.sst-web.tees.ac.uk). Therefore, sensory analysis is indispensable and many food industries integrate this program in their research and development plan.

Acceptability of cheese of which Wagashie is no exception is undoubtedly affected by different and diverse factors such as sensory properties, nutritional information, label, packaging, price etc. (Stone *et al*., 1974). To support this statement, Meiselman *et al*. (1988) commented that acceptability depends partly on the sensory perception of food.

Sensory analysis is applied to better understand cheese sensory attributes basically in three main directions (senses): sensory characterization, consumer preference studies and quality control. Sensory characterization deals with the degree to which the attribute profile of a product under evaluation is perceived. Consumer preference shows the acceptability of a particular product by consumers, in order words the expression of appeal of one product compared to another (Stone and Sidel, 2004). Quality control measures are put in place to ensure that similar products are produced over time consistently. The information generated from these broad groups makes it possible to apply sensory evaluation to predict product shelf-life, map or match products, reformulate products, determine product quality etc (Stone *et al*., 1974).

In the measurement of sensory properties, two main types of sensory tests have been identified- analytical and consumer sensory tests (Stone *et al*., 1974). Furthermore, the analytical type has been categorized into two groups which are discriminatory and descriptive analysis. Discriminatory testing has been applied to products that are not easily discriminable. Additionally, discrimination tests are generally used for measurement of sensitivity to various stimuli or differences between different intensities of a stimulus (O'Mahony and Rousseau, 2002).

2.7.1 *Descriptive Sensory Analysis*

Sensory profiling is a descriptive method that qualifies and quantifies organoleptic properties of products. In order words, sensory characterization of a food product begins with descriptive sensory evaluation that provides a pre-defining terminology for describing sensory perceptions as objectively as possible (Moskowitz, 1983). The terminology is, simply, a set of labels (attributes or descriptors) that a panel has agreed upon that enables them to fully describe the sensory properties of the products being evaluated.

Descriptive sensory analysis addresses some of the problems of language use, interpretation and scaling difficulties. To achieve this, a sensory quality program is organized where time and effort is taken to recruit and train panelists. This procedure also helps to obtain reliable data on the product being evaluated. Sometimes reference samples, if available, are used to calibrate the panel. In some cases, the terms may be selected from previously existing lists, in other cases they may be specifically generated by a panel of assessors (Stone *et al*., 1974).

Methods for generating descriptors are classified according to whether the results are qualitative or quantitative even though one could be transformed to another. An example of a qualitative method is Aroma profile. Examples of the quantitative type are Texture Profile, Quantitative Descriptive Analysis, Free Choice Profiling, Spectrum Analysis, Diagnostic Descriptive Analysis (Stone and Sidel, 1993) and Repertory Grid (Gains 1994).

After the generation of descriptors, it is necessary to determine which of the descriptors sufficiently describe the product. Generally, methods employed for descriptor generation tend to yield many attribute sets many of which are unnecessary and therefore must be reduced to feasible size. This reduction should aim to identify those descriptors that are sufficient to describe the product fully, at the same time avoiding synonymous descriptors or characteristics that are difficult to quantify (Dura´ n *et al*., 1989; Johnsen and Kelly, 1990). To achieve this, statistical methods such as Generalized Procrustes Analysis, Discriminant Analysis, Principal Components, Analysis of Variance etc are employed. In this way, the large list of generated terms is reduced, thus decreasing the time needed for evaluations and making the interpretation of results easier (Gala´n-Soldevilla *et al*., 2005; ISO 11035, 1994).

2.7.1.1 *Training*

Trained panelists have been used to carry out most of the methods put forward for vocabulary generation and assessment of products through sensory evaluation. In fact, standardization institutions (ASTM, 1996; ISO 8586-1, 1993; ISO 8586-2, 1994) recommend performing sensory profiling with a trained or an expert panel. This is necessary because training positions the panelists to adopt an analytical frame of mind. Conversely, untrained consumers tend to act non-analytically when scoring attributes (Lawless and Heymann, 1998). However, free choice profiling which does not require training of panelists has also been used successfully (Gains and Thomson 1990; Guy *et al*., 1989). This methodology has been used for cheeses (R´etiveau *et al*., 2005; Drake *et al*., 2001), for dairy desserts (Gonz´asalez-Tomas and Costell, 2006), and for fresh products.

Recently, many authors have compared the performance of trained and untrained panels, presenting different conclusions. This is so because the studies in both situations varied significantly in terms of the nature and size of the covered product range, the methodology and the data analysis (Labbe *et al*., 2003). Many published studies have demonstrated lack of consensus on the impact of training on sensory descriptive analysis.

In the following publications authors showed that training really impacted on panel performance:

In a research conducted by Wolters and Allchurch (1994) where four different panels each made up of six to eight subjects assessed 16 oranges. It was found that training increased the number of discriminating and consensual attributes of the orange juices. The panels varied in duration of training and in the number of scored attributes (60 h/97 generated attributes, 30 h/70 generated attributes, 15 h/36 pre-defined attributes, 0 h/free choice profiling).

Roberts and Vickers (1994) found that training increased attribute ranking agreement but had insignificant effect on attribute discrimination in a study of five cheddar cheeses. Three different panels varying in size, expertise, duration of training and number of scored attributes assessed the samples (9 assessors/20 h/54 generated attributes, 9 experts/0 h/22 predefined attributes, 18 consumers/0 h/22 attributes forming a subset of the 54 generated).

In a study conducted by Chollet and Valentin (2001), it was concluded that training increased the specificity and precision of the vocabulary of 12 beers. Samples were assessed by two different panels varying in size, duration of training and number of scored attributes (22 assessors/11 h/24 generated attributes, 18 assessors/0 h/22 generated attributes).

In a study conducted by Moskowitz (1996), the author found expertise to have no significant impact on product rating in a study of 37 sauces or gravies for meat or pasta. Samples were assessed using the same predefined glossary (24 attributes) by two different panels varying in size and expertise (12 experts, 225 consumers).

Labbe *et al*. (2003) concluded that the lack of consensus may be due to the different methodologies which were adopted and the context (academic research, industry) within which the study was conducted. In a typical industry setting, Labbe *et al*. (2003) supported the fact that training indeed had an influence on the reliability of sensory profiling. In their study, untrained panel was made to assess eight soluble coffees, representative of a benchmarking study. Training sessions were organized for the subjects, after which they were asked to assess these products again. The results showed that training was indeed necessary. Interestingly, their findings agreed with those of Wolters and Allchurch (1994), Roberts and Vickers (1994), and Chollet and Valentin (2001).

Even though some authors have seen no impact on training, many agree that training is necessary in carrying out a descriptive sensory evaluation. Training, in fact, orients the minds of the panel to have a common understanding of the meanings of the attributes selected and score products in a similar and objective way. For consumer acceptance untrained panel always provides reliable information since scoring is based on preference rather than description.

2.7.1.2 *Description of Cheese*

Often terms that are used to describe the characteristics of cheese do not give satisfactory description of the product. Some of these terms are unclean and over-matured, these attributes cannot be clearly defined. More often than not, judges have used the term 'unclean' for a range of unpleasant aromas that vary both in aroma character and intensity (Dunn and Lindsay 1985). State graders have been reported to have described defects in cheeses as over-matured, unclean and onion-like, whereas a "taste panel' described the off-aromas as fruity, fermented, rancid, burnt, sulphurous or unclean (Aston *et al*., 1985). Developing proper descriptive terminology and reference standards are, therefore, important for testing of any product (Rainey, 1986).

Description of aroma based on clearly defined terminology for sensory components have been published for some natural cheeses. Vangtal and Hammond (1986), adopted definable attributes such as acid, afterburn, bitter, burned, buttery, fruity, heavy metal, moldy, nutty, salty, and sweet to describe Swiss-type cheese. These attributes were selected in other that the aroma characteristics could be related to the chemical parameters. In addition, they used a general term "cheddar" and a consumer type attribute "unclean" to describe the cheese. In a research conducted by Rothe *et al*. (1978), sixteen different attributes were generated for eleven different cheeses. The attributes included total impression, fruity, sour, milky, yogurt-like, butter-like, caramel-like, fatty acid, off-flavor, sharp cheese, stinky, bitter, salty, and fungal. In addition to definable flavor descriptors, the list included names of cheeses such as Emmentaler, Romadur, and Roquefort to describe cheese flavor.

In an aroma sensory evaluation conducted by highly trained panel on 42 cheeses, the aroma attribute assigned to feta cheese, a soft cheese of Greek origin made from sheep milk, was pungent. Other soft cheeses which had the same aroma characteristic were Blue cheese (Denmark, Cow), Brie (France, Cow), Chevre (France, Goat) and Limburger (West Germany, Cow). The pungent aroma was defined as 'the sharp physically penetrating sensation in the nasal cavity' and was referenced as 'a ratio of 1 part of sour cream to 0.68 horse-radish (Reese)' (Heisserer and Chambers, 1993).

2.8.0 Cooking practices and their effect on the sensory perception of foods

With the exception of some fruits and vegetables, most foods are eaten in their cooked forms. Different cooking practices give foods unique characteristics. Examples of cooking practices practiced in our homes are boiling, roasting, frying etc. some of the cooking practices cheeses undergo are pasteurization of milk prior to cheese production, pressing of the cheese, and sometimes frying.

2.8.1 ***Pasteurization and heating***

"Pasteurization is the act or process of heating a beverage or other food, such as milk or beer, to a specific temperature for a specific period of time in order to kill microorganisms that could cause disease, spoilage, or undesired fermentation" (www.answers.com). Pasteurization, even though, kills pathogenic microbes also destroys some useful microbes and some nutrients (vitamin C) in the milk (www.realmilk.com).

Pasteurization or heating of milk for a long period of time causes evaporation of the milk water and concentration of the oil making the milk creamier. In a research conducted by Braga and Palhares, (2007) to determine the effects of evaporation and pasteurization on the biochemical, immunological composition and osmolarity of human milk. They observed a concentration of the constituent of the milk as a result of removal of water due to evaporation. Cheeses made from milk pasteurized for a long time have creamy appearance and appear firmer than cheeses from unpasteurized milk that have white appearance and softer texture.

2.8.2 ***Draining or Pressing***

Cutting and scalding of curd during the process of cheese production contributes to the reduction of moisture in the final cheese. Pressing which is commonly done in cheese production leads to substantial removal of water. Normally the curds are placed in cheese cloths wrapped and weights put on them. Sometimes the cheese cloths containing the curds are hanged and the whey allowed to drain under gravity. The expulsion of whey from the curds makes them firmer; the extent of the firmness developed by the curd depends of the degree of whey drainage.

2.8.3 *Frying*

Frying is a process of cooking food using oil as the heating medium and can be classified as pan-frying and deep-frying. In pan-frying the food is moistened with fat, but not soaked. In deep frying the food is immersed in the oil which is enough to cover it, it is a process of cooking and drying through contact with hot oil. During frying, oil is taken up into the product as a result of capillary pressure difference as water is removed from the product. Crust formation as a function of rise in the temperature of the product reduces oil uptake. Majority of the oil content of many foods results from absorption of oil when the product is removed from the oil, as the product is taken out of the oil, its temperature and the pressure inside the crust pore spaces decreases resulting in an increase in oil absorption. Most deep fried products such as Wagashie have soggy appearances due to the substantial amount of oil they take up during frying (http://books.google.com).

2.9 Sensory Perception of Preserved Cheeses

Most cheeses undergo maturation during storage, the storage techniques most often lead to a controlled ripening of the product resulting in the attainment of cheeses with desirable sensory characteristics after the storage period. However, the onset of ripening in some cheeses like Wagashie and Feta is regarded as the onset of spoilage since they are consumed in their fresh (unripened) form. Therefore, the storage technique employed must lead to insignificant microbiological, physical, chemical and sensory changes in the product.

The impact of storage technique and period on the sensory perception of cheeses has been researched into. In a research conducted by Abdalla and Mohamed (2009) on the effect of time on the sensory characteristics of vacuum packaged cheese of Sudan origin over a forty-five day storage period at 4^{o}C, the colour and body of the cheese samples did not change. However, changes were observed in the flavour, taste, saltiness and overall acceptability after storage. Romani *et al*. (2002) observed no correlation of moistness sensory attribute with moisture content of vacuum packaged Parmigiano Regiano cheese after ninety days of storage at 4^{o}C. No changes in the intensity of aroma were observed in the cheese but a significant increase of the sourness of the cheese just after the first month of storage was observed through to the end of the storage period. Texture profile analysis showed a reduction in the hardness of the cheese after the storage period. Also, a significant increase in cohesiveness and elasticity at the end of storage period was observed. They concluded that fat migration phenomena observed in vacuum packed cheese may be responsible for the change towards a less friable and more elastic structure.

Conclusion

Wagashie, a West African soft cheese, has a high pH (about 6.0), moisture (about 50%) and low salt content, and rich nutritional composition when freshly prepared. This makes the dairy product perishable and therefore very susceptible to spoilage by moulds, yeasts, and *Enterobacteriaceae*, especially under ambient temperatures; at this temperature it has a shelf-life of about 2-3 days in its whey. Few preservative methods have been carried out to prolong the shelf-life of Wagashie; these methods either altered the sensory appeal of the freshly prepared samples or compromised the safety of the product due the preservative chemical incorporated.

In order to maintain the freshness of Wagashie for a considerable period of time without the use of preservatives, vacuum-packaging (VP) may be employed. A combination of low density polyethylene and aluminum foil may, synergistically, extend the keeping quality of Wagashie for about 20-30 days under cold condition by controlling the growth of microbes, and retarding the influx of moisture and oxygen to and from the product.

In view of the high moisture content of traditional Wagashie which may compromise the preserving capability of the package because of liquid exudation, this research seeks to come up with Wagashie samples with reduced water content and thus have better stability than the traditional type.

Sensory evaluations conducted on Wagashie have focused on consumer acceptance (Appiah, 2000; Ashaye *et al*., 2006) none have been done with the aim of developing descriptive vocabulary for the product. This research also seeks to develop a lexicon for Wagashie.

CHAPTER 3

3.0 MATERIALS AND METHODS

3.1 Sources of Materials

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 the Greater Accra region. The flexible plastic pouches and aluminium foil were purchased from Danica Plastic Ltd (Kasoa) and Mokola market respectively.

3.2 STATISTICAL ANALYSIS

Analysis of Variance (ANOVA) on the data and graphical representation of the results were carried out using Statistical Package for Social Sciences Windows 16.0 (SPSS) and Excel (2003) respectively. Where variations were observed among the four Wagashie samples at 5%, Least Significant Difference (LSD) was carried out to determine the sources of variation. Pearson's correlation was carried out using SAS version 8.

3.3 PREPARATION OF WAGASHIE

Three different samples of Wagashie were produced; they were Wagashie from Unpasteurized Full-Fat milk (UFFM), Pasteurized Partially Skimmed milk (PPSM) and Pasteurized Full-Fat milk (PFFM). A commercial product (D) that served as control was purchased from the nima market in Accra, Ghana. The production of these Wagashie types was preceded by stock preparation.

3.3.1 *Stock Preparation*

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

Stock Preparation Step

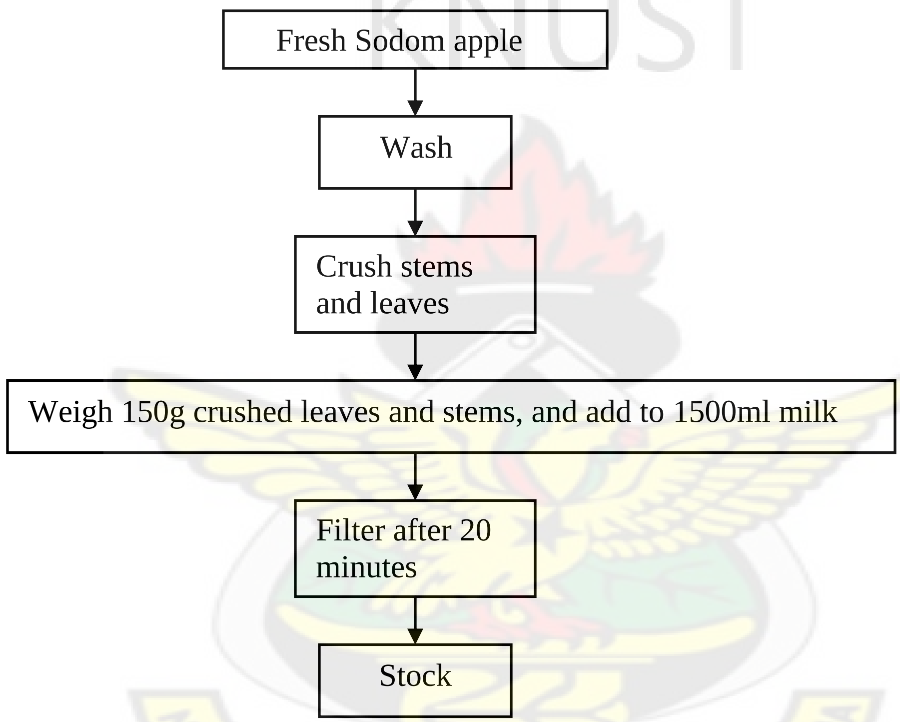


Figure 1: Flow chart of stock

3.3.2 *Wagashie Preparation*

Each of the three different samples of Wagashie was prepared with six litres (6L) of fresh milk.

The milk for sample (PPSM) and (PFFM) was pasteurized at 75ºC for 10 minutes and then cooled. The fat that settled on top of PPSM milk was scooped before the end of pasteurization. Together with UFFM milk, PFFM and PPSM milk were kept in a refrigerator (4ºC) overnight.

The Preparation step:

Six litres of milk was heated to a temperature of 55ºC. At this temperature, 500ml of the stock was added. The milk was stirred and the temperature was gradually raised up to 85ºC, five minutes 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 curds were collected into cheese cloth, tightened and hung to allow the whey to drain by gravity for an hour. After an hour of hanging, the mass of curd was comminuted into pieces and 0.3g of salt added; the salt was mixed well with the comminuted curds. The pieces of curds were repacked into the cheese cloth; the cheese cloth was squeezed and hung again with 5kg weight place on it to allow more whey drainage for 30 minutes. After 30 minutes of hanging the matted curd was removed from the cheese cloth and then packaged.

Wagashie Preparation Step

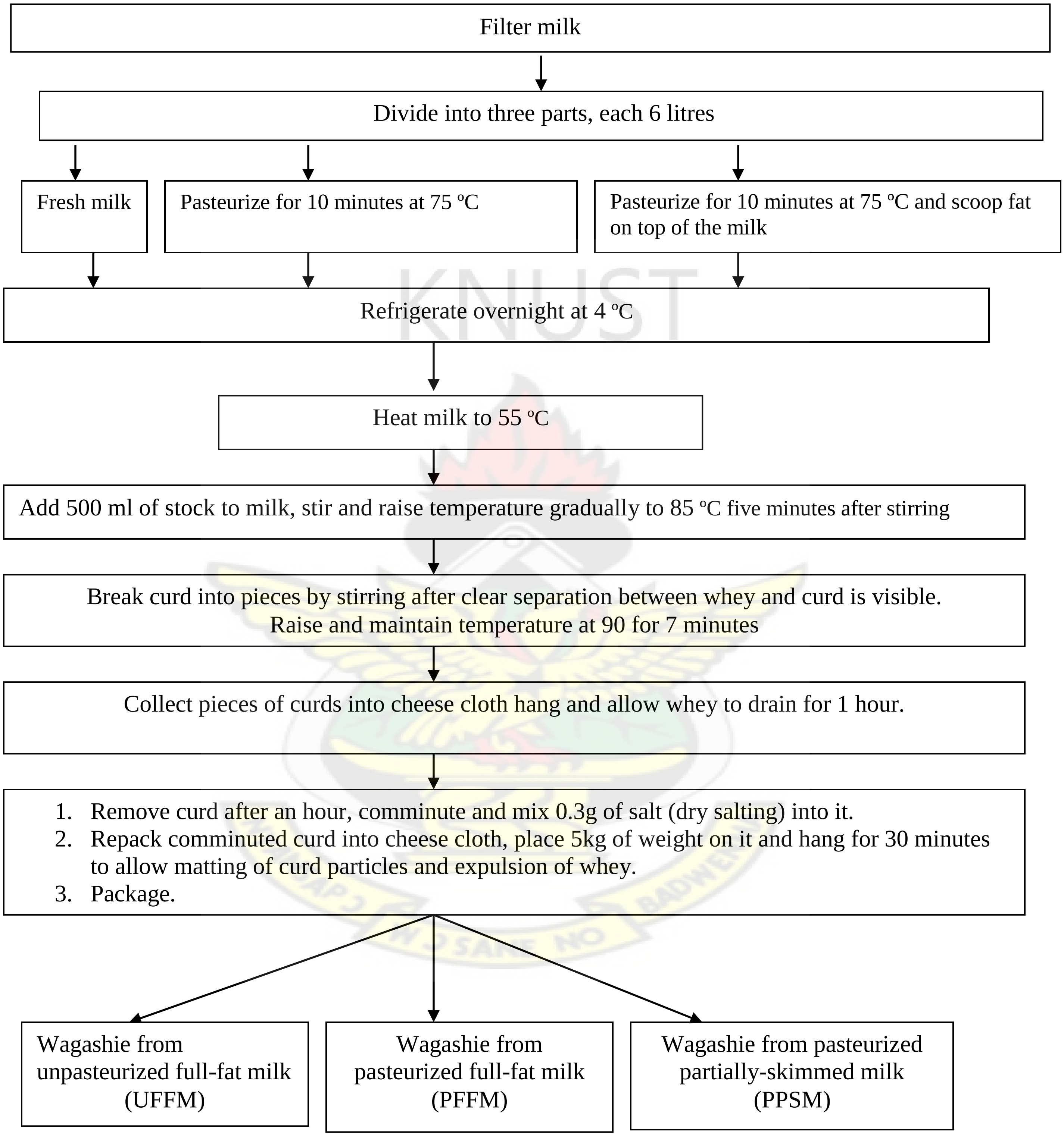


Figure 2: Flow chart for Wagashie

The Wagashie samples were grouped into two batches, the first for chemical analysis and the second sensory evaluation.

3.4 Packaging and Storage

Each of the four Wagashie samples making up the first batch was cut into strips of 5cm x 2cm x 2cm dimension. Each strip was wrapped with cling film (made from low density polyethylene) and then wrapped with aluminium foil of thickness 91.1µm. Ten of the sample strips were placed in a vacuum pouch (made from a combination of linear low and high density polyethylene) of thickness 87.5µm and dimension 17cm x 17cm.

The second batch was divided into two groups, the first group was used for generation of descriptors and sensory evaluation. 500g of each of the four samples making up the second group was packaged, stored for four weeks and then sensory evaluation carried out at the end of the storage period.

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. Samples for sensory evaluation were taken out after four weeks of storage. However, one pack of each Wagashie kind was randomly picked on the first, second and fourth week for chemical analysis. Before storage was started, chemical analysis was conducted on samples of each type of Wagashie; this represented results for week zero.

3.5 SENSORY EVALUATION

Quantitative descriptive analysis adapted from Stone and Sidel (1993) was used for the recruitment and training of panel for descriptive vocabulary generation for Wagashie.

3.5.1 Selection of Panel

20 employees of Food Research Institute, Council for Scientific and Industrial Research, took part in the training session.

3.5.1.1 *Product Attitude Survey (PAS) and Screening*

A Product Attitude Survey form (Appendix A) was designed and distributed to prospective panelists of Food Research Institute to gather demographic and background information. The form also helped in identifying individuals who like or dislike the product and their availability for training and evaluation of the products.

A discriminatory test which reveals the ability of subjects to recognize differences or similarities among different or similar products was not carried out since the records of the panel showed that they participated regularly in sensory evaluations.

3.5.2 *Training*

Training of the panelists for the quantitative descriptive analysis included product orientation, development and grouping of descriptors by modality, development of consensus language, definition of descriptors, and familiarization of panelists with test procedures (Stone and Sidel, 1993b). A total of four hours was spent on training (two hours in the morning and two in the afternoon).

3.5.2.1 ***Product orientation***

The panel was briefed on the historical background and processing method of the traditional Wagashie product since majority of the members were unfamiliar with it.

3.5.2.2 ***Development and grouping of descriptors by modality***

D and PFFM were chosen for their contrasting appearances. The traditional type (control) of Wagashie was introduced to the panelists as a typical Wagashie in its cooked and fried form and they were asked to, individually, write down all attributes they feel describes the product in its entirety, the same was done for PFFM sample in both cooked and fried forms. The attributes proposed by the panelists and the number of occurrences of each were listed on a board under the modalities of colour, appearance, texture, aroma and taste.

3.5.2.3 ***Development of consensus language***

A definition for each of the attributes agreed upon was developed by the panel. Duplicate or synonymous words identified were eliminated and attributes discussed thoroughly to the comprehension of the panel. Simple references where provided for all the descriptors except aroma. The significance of the references provided was to promote descriptor understanding among the panelists.

3.5.2.4 ***Familiarization of panel with test procedures***

In view of the experience of the panel with regard to the use of the line scale, the bipolar unstructured 10 cm line scale was only reviewed.

3.5.2.5 *Practice of Scoring and Assessment of the Performance of Panel*

Prior to the main sensory evaluation, a pre sensory evaluation was conducted where D and PFFM samples in their cooked forms were evaluated by the panelists on the attributes agreed upon to assess their performance. The evaluation was done on the bipolar unstructured 10cm horizontal line (Appendix B) anchored by high (strong) and low (weak) intensities of the attributes. For instance on attribute ‘Rough’, the left side of the line was anchored by ‘rough’ (0cm) and the right side ‘smooth’ (10cm). Panelist’s ability to agree with other members of the panel on the definition and use of agreed descriptors was expressed in terms of the percentage relative error of that panelists score with the mean score of the whole group. Panelists with percentage score between -50% and +50% in more than four evaluations were chosen (Appendix N). It was on this basis and availability of the panelists for evaluation that 10 (two women and eight men) persons were selected to participate in the main sensory evaluation.

3.6 Main Sensory Evaluation

3.6.1 *Experimental design*

Balanced-Block Design was adopted where the order of presentation of the samples were randomized to prevent any biasing effect. Sessions took place in a sensory evaluation laboratory equipped with individual assessment booths and uniform lighting conditions. Traditionally, Wagashie is fried without taking into consideration the temperature of the oil. However, to guarantee test repeatability, the four samples were fried separately in oil (‘frytol’) at a temperature of 109 ºC for three minutes. Serving was done after the temperature of the samples had dropped to 40ºC.

Evaluation was carried out on the freshly prepared fried Wagashie samples (week 0) and then repeated after four weeks on the stored ones (week 4). Preliminary survey showed that Wagashie is mostly consumed in the fried form. In view of this, evaluation was carried out on the fried forms. Prior to the serving of the stored Wagashie, 500g of each of the four stored samples was boiled in one litre volume of water for 15 minutes to reduce any possible increment in the microbial population which might have occurred during the storage period. The samples were cut into 4cm x 3cm x 3cm, fried, maintained at 40ºC and then served on white disposable plates coded with randomly selected three digit numbers. Cracker biscuits without salt and water were provided to each panelist, the panelists were asked to clean their palate before and after each tasting. The scoring of the attributes was done on bipolar unstructured 10cm line intensity scales.

Three sessions of scoring were held on each scoring day resulting in a total of 24 samples (12 for week zero and 12 for week four) being evaluated by each panelist. The scoring was done in one day with two hours break interval after two sessions of scoring; this was done to reduce fatigue. The next evaluation was held a day after the fourth week storage period.

3.7 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).

3.7.1 *Moisture*

Five grams of well-mixed portion of the sample was weighed on an analytical balance with an error of 0.0001g. This was preceded by heating the metal can made of alumina for 20 minutes at 103 ± 2°C and cooling in a desiccator to constant weight. The can with the sample was then dried in an oven (Genlab Ltd, England) at 103 ± 2°C for 4 hours. The drying started at the time the oven attained a temperature of 103± 2°C. The % moisture was determined at room temperature according to the calculation below.

$$\text{Moisture (\%w/w)} = \frac{[(\text{wt of dish + fresh sample}) - (\text{wt of dish + dried sample})]}{[(\text{wt of dish + fresh sample}) - (\text{wt of dish})]} \times 100\%$$

3.7.2 *Protein*

Kjeldahl method was used to determine the crude protein content of the samples. 0.2g of a well homogenized sample was weighed on a filter paper. The filter paper holding the sample was folded and then dropped into a digestion tube. 15ml of concentrated sulphuric acid and a tablet of catalyst (Kjeltab) were added. The whole mixture was then placed in a digester set a 400 ^{o}C. Digestion was stopped when the mixture changed from black to green colour. Digestion was then followed by distillation with 80ml of water and 80ml of 40% sodium hydroxide in a distillation unit. During distillation the steam generated by a heating apparatus distilled the ammonia and water into a receiving flask containing 25ml of boric acid. Titration of boric acid and $NH_3 + H_2O$ formed with standardised 0.1M HCl was done and this resulted in a pinkish colour formation at the end point. A blank was run under the same condition as with the sample. Total nitrogen content was then calculated according to the formula:

$$\frac{\text{(Titre (of sample) – blank) x concentration of standardised HCl x 14.007}}{\text{10 x weight of sample}}$$

The total nitrogen was converted to crude protein by multiplying it with 6.25.

3.7.3 *FFA*

To 40ml ethanol, few drops of phenolphthalein was added and neutralised with 0.1N sodium hydroxide. The neutralised ethanol was added to about 5 g of well-mixed sample; the mixture was then boiled on hot plate and titrated with 0.1N NaOH. The titre was recorded and the FFA was determined according to the calculation below:

$$\text{FFA} = \frac{\text{Titre x Normality of NaOH (0.1) x Factor of dominant acid (Oleic)}}{\text{10 x weight of sample}}$$

The FFA determined was expressed as oleic acid.

3.7.4 *Fat*

About 2g of the macerated sample was dried in an oven as described for moisture determination above. The dried sample was then placed in an extraction thimble and then stopped with grease-free cotton. Before extraction was commenced the round bottom flask was dried, cooled and weighed. The thimble was placed in extraction chamber and 240ml petroleum ether added to extract the fat. The extraction was done for a period of 15 hours at a condensation rate of 5-6 drops per second. The fat extracted was then dried in an oven at 103 ± 2^{o}C for 1 hr. The dried fat was cooled and weighed after the 1hr drying process. A blank was run by following the same procedure as with the sample but this time the sample was omitted.

Calculations:

%Fat = <u>(wt of flask and sample after extraction – wt of empty flask) - Blank</u>

(Wt of flask and sample – wt of empty flask)

Blank = wt of flask without sample after extraction – wt of empty flask

For fat on dry basis

(<u>100% – moisture x fat extracted in dry basis</u>),

100%

3.7.5 *pH*

A lab pH meter (pHm 92313ri2n017, Denmark) was used for the measurement of the pH of the samples. 5g of the macerated test sample was diluted with 5ml of distilled water. The measurement was taken electronically against two reference buffer solutions (4.01 and 7).

CHAPTER 4

4.0 RESULTS AND DISCUSSION

4.1 *Demographic and Background information about the respondents*

Forty questionnaires were distributed; however, twenty-five filled ones were received. Only ten out of twenty-five respondents had knowledge about Wagashie. Of the ten, three had tasted the product before, and the seven respondents had heard about the product but not tasted it before. Of the seven who had not tasted the product, three got their information from Muslim friends, two from school and the other two from radio. Two out of the three who had eaten Wagashie before did so frequently and were from Northern and Volta regions of Ghana, the third person had tasted it once.

Four declined to participate in the training because of other engagements at the scheduled day and one disliked Wagashie and therefore opted out of the training. Twenty persons accepted to participate in the training and were made up of nine males and eleven females aged between 21 and 55 years; six (three males and three females) were students on industrial attachment and the rest were full-time employees of the institute. Four of the respondents were from the Volta region of Ghana, two Eastern region, seven Greater Accra region, four Western region, three Brong Ahafo region and three Ashanti region. Only two were from the northern regions. However, they all reside in Accra.

4.2 Generated attributes and their occurrences.

A total of twenty-five (25) descriptors (attributes) were suggested by the panel to describe the sensory perception of two Wagashie samples (PFFM and D) in their cooked and fried forms. The total number of descriptors generated and the number of times used by the panel are presented in Table 4.0. The most frequently used descriptors were 'rough surface' which was used thirty-three times (14.1%), 'light brown' twenty-two times (9.4%), 'soggy' twenty-one times (9%), 'creamy' eighteen times (8%), 'white' sixteen times (7%) and 'crumbly' fifteen times (6.4%) . This implies that the panel paid much attention to the colour, appearance and texture of the Wagashie samples. The rest of the attributes were used less than fifteen times.

Table 4.0: Total attributes and their respective occurrences for selected Wagashie in their cooked and fried forms

SAMPLE	ATTRIBUTE	OCCURRANCE
	Colour	
Cooked D	White	16
	Dirty-white	2
Cooked PFFM	Slightly cream	2
	Creamy	18
	Yellow	2
Fried D	Light brown	10
	Brown	6
	Golden brown	4
Fried PFFM	Light brown	12
	Brown	5
	Brown with cream traces	1
	Golden brown	2
	Appearance	
Cooked D	Smooth surface with holes	3
	Irregular holes	14
	Rough	1
	Compact	6
Fried D	Rough Surface	13
Cooked PFFM	Rough Surface	19
Fried PFFM	Crumbly	15
	Texture	
Cooked D	Soft	11
	Springy	5
	Chewable	14
Fried D	Soggy	8
Cooked PFFM	Firm	10
Fried PFFM	Friable	1
	Soggy	13
	Aroma	
Cooked D	Milk-like	2
	Cheese-like	3
Fried D	Egg-like	2
Cooked PFFM	None	0
Fried	None	0
	Taste	
Cooked D	Egg-like	4
	Unsweetened fresh-milk	1
	No taste	7
Fried D	None	
Cooked PFFM	Egg-like	2
Fried PFFM	None	

4.2 *Final vocabulary set*

Through open discussion and consensus twenty attributes (eleven for cooked and nine for fried Wagashie samples) were agreed upon to adequately describe the sensory perception of Wagashie sample D and PFFM. Tables 4.1 and 4.2 show the final set of descriptors agreed upon, their definitions and references. Plate one shows the pictures of the four Wagashie samples studied

UFFM

PPSM

PFFM

D (CONTROL)

FRIED WAGASHIE (D)

Plate 4.0: Pictures of the Wagashie samples studied

TABLE 4.1: FINAL ATTRIBUTES GROUPED BY MODALITIES FOR SELECTED WAGASHIE SAMPLES

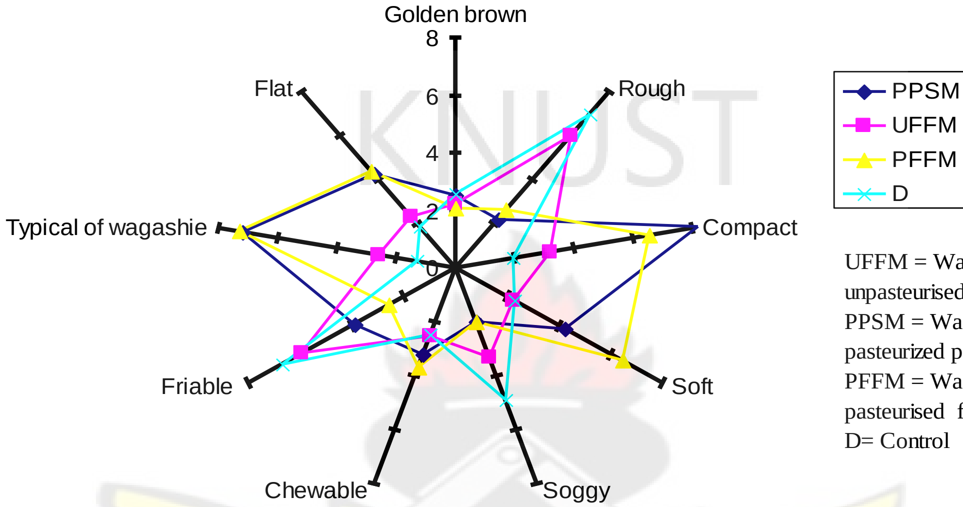
Cooked D and PFFM	*Fried D and PFFM*
Colour Broken-white (D) Creamy (PFFM)	**Colour** Golden brown (both)
Appearance Open (both) Rough surface (both) Compact (both)	**Appearance** Rough surface (both) Compact (both)
Texture (Hand-feel) Springy (both) Firm (both)	**Texture (Hand-feel)** Firm (both) Soggy (both)
Texture (Mouth-feel) Chewable (both) Friable (both)	**Texture (Mouth-feel)** Chewable (both) Friable (both)
Aroma Typical Wagashie (both)	**Aroma** Typical Wagashie (both)
Taste Flat (both)	**Taste** Flat (both)

Table 4.2: Definitions and References for Final Descriptors Grouped by Modalities

ATTRIBUTE	DEFINITION	REFERENCE
Colour		
Broken-white	Broken –white colour.	Cloth with broken white colour.
Creamy	Cream colour.	Picture of cream colour.
Golden brown	Golden-brown colour.	Picture of golden-brown colour.
Appearance		
Open	Extent to which the cut surface of Wagashie has holes (pinholes, cracks or irregularly shaped holes).	A picture of Swiss cheese.
Rough surface	Extent to which the surface of the Wagashie is rough.	The surface of HobNob digestive biscuit.
Compact	Extent to which the particles of the cheese mat to each other.	Finely moulded cassava dough.
Texture (Hand feel)		
Springy	Extent to which the cheese regains it shape and form when a slight pressure from any of the fingers is applied on it.	A day old sugar bread.
Firm	Extent to which the sample yields to pressure from any of the fingers.	Boiled hard egg.
Soggy	Oily nature of fried Wagashie when felt between the fingers.	Freshly fried beef.
Texture (Mouth feel)		
Chewable	Easiness with which Wagashie morsel is broken down by the molars.	Fried Soya bean 'khebab'.
Friable	Easiness and extent to which the Wagashie breaks and fills the mouth when chewing is initiated.	Tiger nut.
Aroma		
Typical Wagashie	Aroma of a typical Wagashie.	None.
Taste		
Flat	Wagashie sample having no taste.	Unsweetened fresh milk.

4.3 *Sensory comparison of the fresh (zero week old) Wagashie samples*

Statistically, the attributes for the four different samples (figure 4) showed differences (P< 0.05) except for golden brown colour attribute.



UFFM = Wagashie from unpasteurised full fat milk
PPSM = Wagashie from pasteurized partially skimmed milk
PFFM = Wagashie from pasteurised full fat milk
D= Control

Figure 4: Cob-web diagram for sensory attributes of fried Wagashie samples evaluated at week zero.

[n = 30; 10 panelists with three replications. Wagashie samples were all significantly different (P< 0.05) with regard to their sensory attributes except for golden brown].

The Wagashie samples were similar (P> 0.05) with respect to attribute golden brown. Wagashie sample D and UFFM showed close association under all the sensory profiles, likewise PPSM and PFFM. The similarities showed by D and UFFM may be due to the unpasteurized milk that was used in their preparation. Even though the preparation of D was not known (because it was purchased from the market), it could be said that it was prepared from unpasteurized milk since Wagashie is traditionally prepared from this kind of milk. The similarities shared by PPSM and PFFM may be due to the pasteurization and the cooling process the milk was subjected to prior to their preparation.

Even though sample D and UFFM showed similarities they were significantly different ($P < 0.05$) under attributes rough, compact, soggy, friable and typical of Wagashie (appendix C3). PPSM and PFFM also showed significant difference ($P < 0.05$) under compact, soft, friable. The mean range score was narrow for golden brown (2.09-2.54), soggy (1.98-4.88), chewable (2.45-3.67) and flat (1.87-4.41) but large for the rest. This indicates that all the Wagashie samples were perceived as golden brown, soggy, chewable and flat because their mean scores were less than five, though the panel detected significant differences among the Wagashie samples in terms of attributes soggy, chewable and flat.

4.4 *Sensory comparison of zero week (fresh) and four weeks old (stored) Wagashie samples*

COLOUR

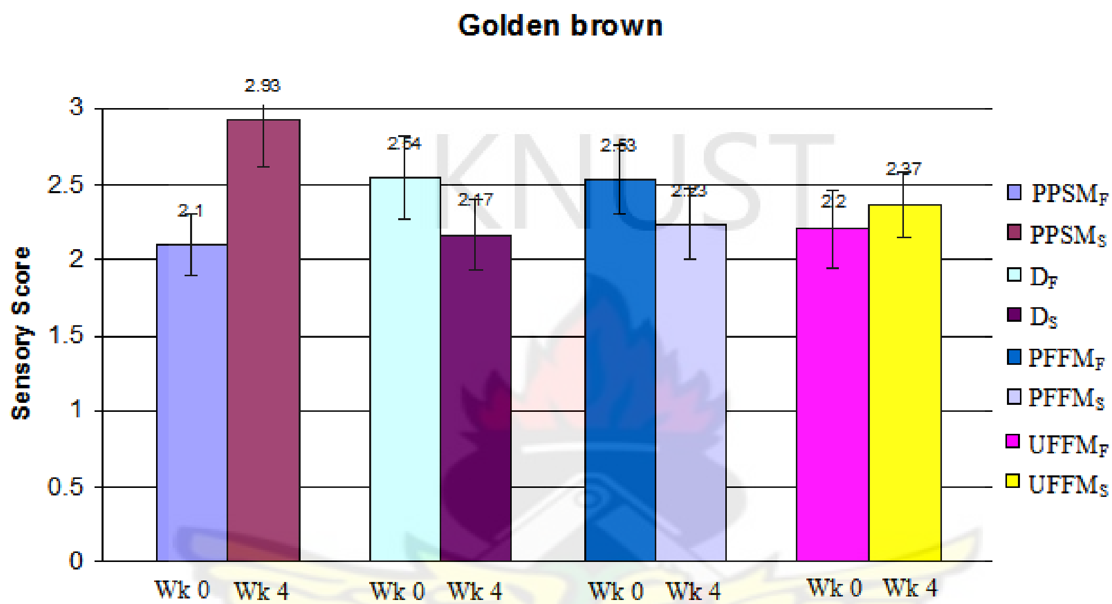


Figure 4.1: Comparison of 'Golden brown' mean score of fried fresh (week zero) and stored (week four) Wagashie samples. [0= Golden brown, 10= Not golden brown].

[The error bars indicate significant difference or otherwise at 5% confidence level (n=30; 10 panelists with three replications)].

The subscripts F and S stand for fresh and stored respectively.

All the Wagashie samples after storage were similar to their fresh forms (P> 0.05) in terms of golden brown colour (figure 4.1) except sample $PPSM_S$ that was different (P< 0.05) from $PPSM_F$. However, the mean score of all the samples were below 5 indicating that they were perceived as golden brown.

The general stability of the colour of the samples after the storage period is consistent with the results of Abdalla and Mohamed (2009). They observed no change in the colour sensory attribute of the vacuum packaged cheese they studied at the end of the storage period. Also, Tejada *et al*. (2007) observed no significant change in colour attributes of ripened cheese coagulated with plant based coagulant.

APPEARANCE

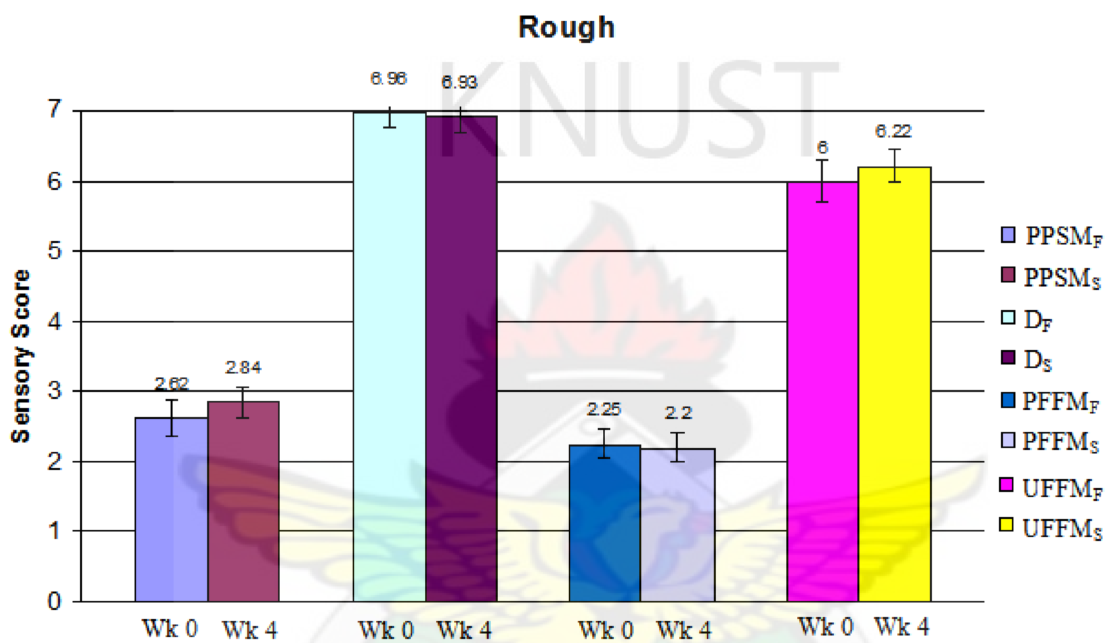


Figure 4.2: Comparison of 'Rough' mean score of fried fresh (week zero) and stored (week four) Wagashie samples. [0= Rough, 10= Smooth].

[The error bars indicate Significant difference or otherwise at 5% confidence level (n=30; 10 panelists with three replications)].

No significant change ($P > 0.05$) occurred in all the Wagashie samples after the storage period in terms of attribute rough (figure 4.2). Wagashie sample PPSM and PFFM were perceived as rough (since their mean scores were less than 5) and sample D and UFFM were perceived as less rough (since their mean scores were greater than 5) after the storage period.

In terms of the appearance attribute compact (figure 4.3), samples PPSM and D remained unchanged ($P > 0.05$) after the fourth week of storage, however, samples PFFM and UFFM became more compact (P< 0.05). The increase in the compactness of the samples may be attributed to the breakdown of protein structure of the product during ripening (Fox, 1989).

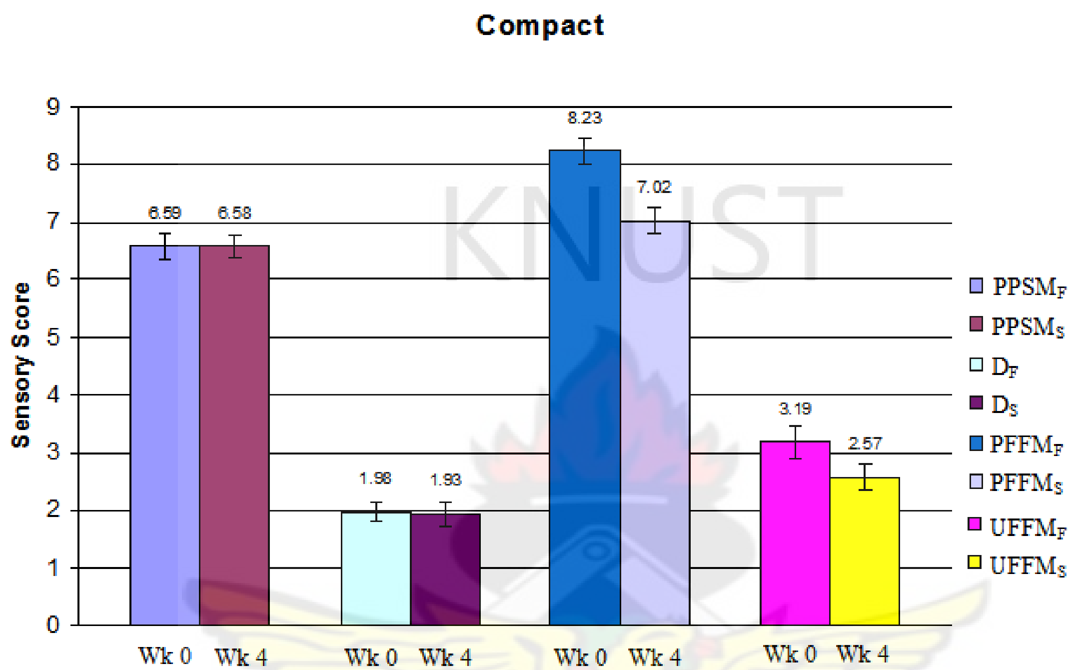


Figure 4.3: Comparison of 'Compact' mean score of fried fresh (week zero) and stored (week four) Wagashie samples. [0= Compact, 10= Not compact].

[The error bars indicate Significant difference or otherwise at 5% confidence level (n=30; 10 panelists with three replications)].

TEXTURE

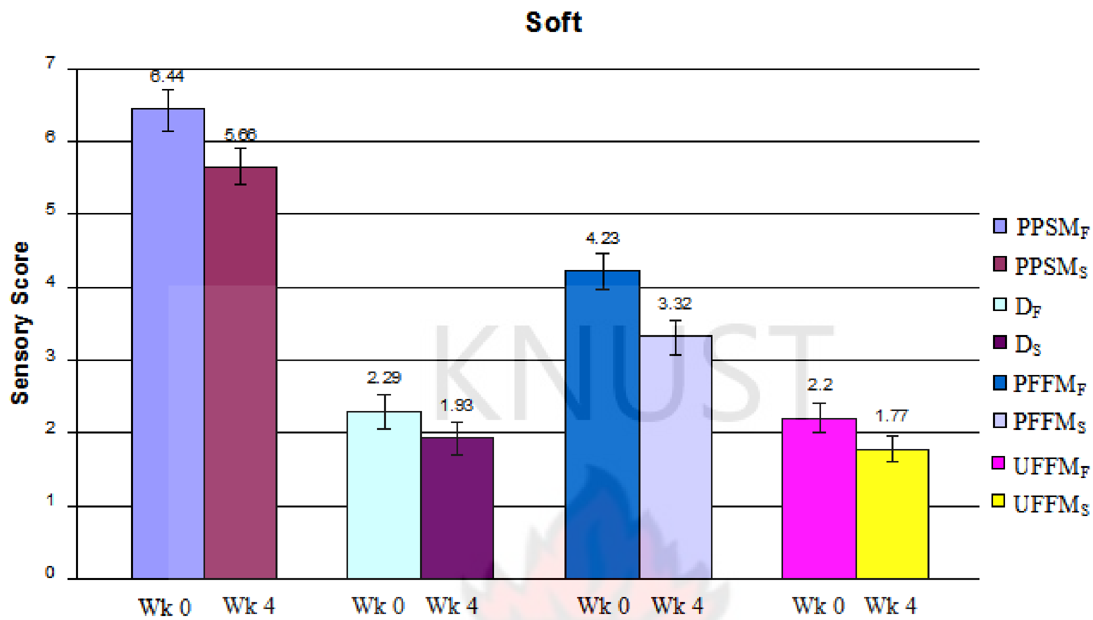


Figure 4.4: Comparison of 'Soft' mean score of fried fresh (week zero) and stored (week four) Wagashie samples. [0= Soft, 10= Hard].

[The error bars indicate whether the differences are significant or not at P= 0.05 (n=30; 10 panelists with three replications)].

All the Wagashie samples showed significant increases in their softness (P< 0.05) except sample D (figure 4.4). Even though a reduction in the moisture content of all the samples after storage was suppose to prompt a reduction in their softness, this did not happen. The softness of the all the samples may be due to the excessive proteolytic activity that took place in the cheese matrix during ripening breaking down the protein network (Sousa *et al*., 2001). Cheeses made with vegetable coagulants prompt intense proteolysis, breaking up casein network and giving rise to a more homogenous structure thus softening the cheese (Tajeda *et al*., 2007). Rohm *et al*. (1992); Yun *et al*. (1993); Ucedaq *et al*. (1994); Ustunol *et al*. (1995); Romani *et al*. (2002) have all reported an indirect correlation of proteolysis with hardness in cheese.

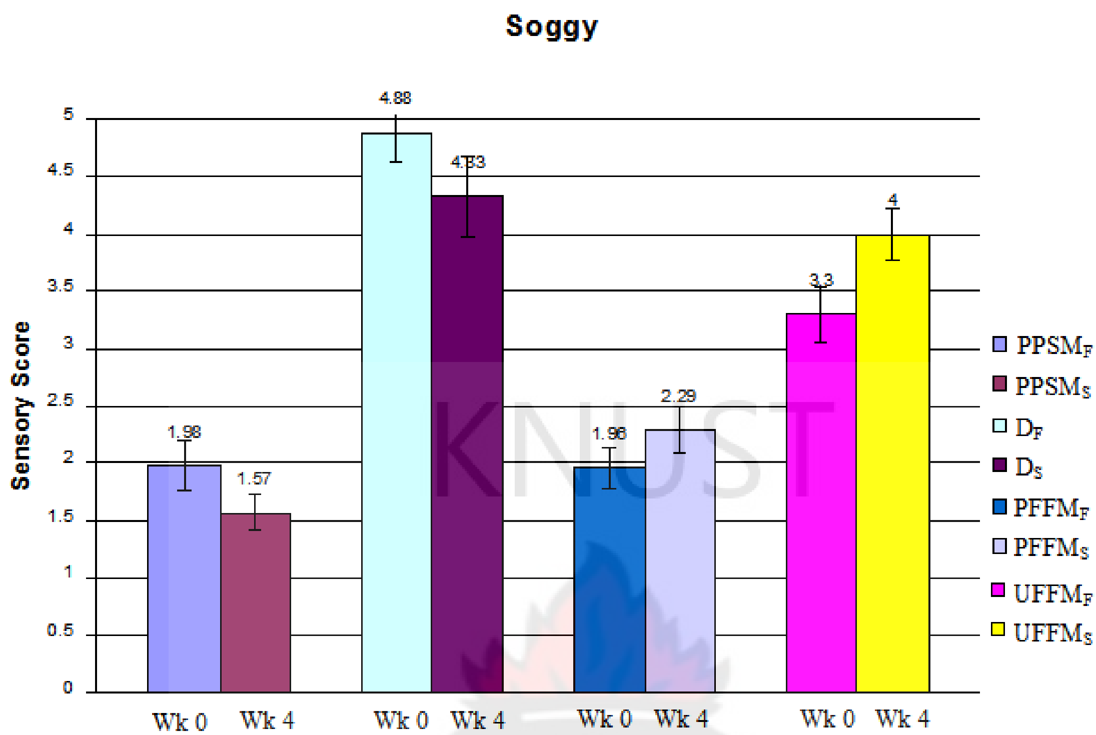


Figure 4.5: Comparison of 'Soggy' mean score of fried fresh (week zero) and stored (week four) Wagashie samples. [0= Soggy, 10= Not soggy].

[The error bars indicate Significant difference or otherwise at 5% confidence level (n=30; 10 panelists with three replications)].

All the Wagashie samples in both fresh and stored forms absorbed much oil after frying since their mean scores were less than 5 (figure 4.5); this is typical of deep fried products. Oil was taken up as water was removed from the product as a result of the capillary pressure difference created during frying. More oil was absorbed by the product after the product had been removed from the oil due to the decrease in the temperature and pressure of the crust pores resulting in this observation (http://books.google.com). Comparison of the stored Wagashie samples with their fresh ones showed no significant difference (P> 0.05) except for sample $UFFM_S$ which absorbed significantly less oil compared with $UFFM_F$.

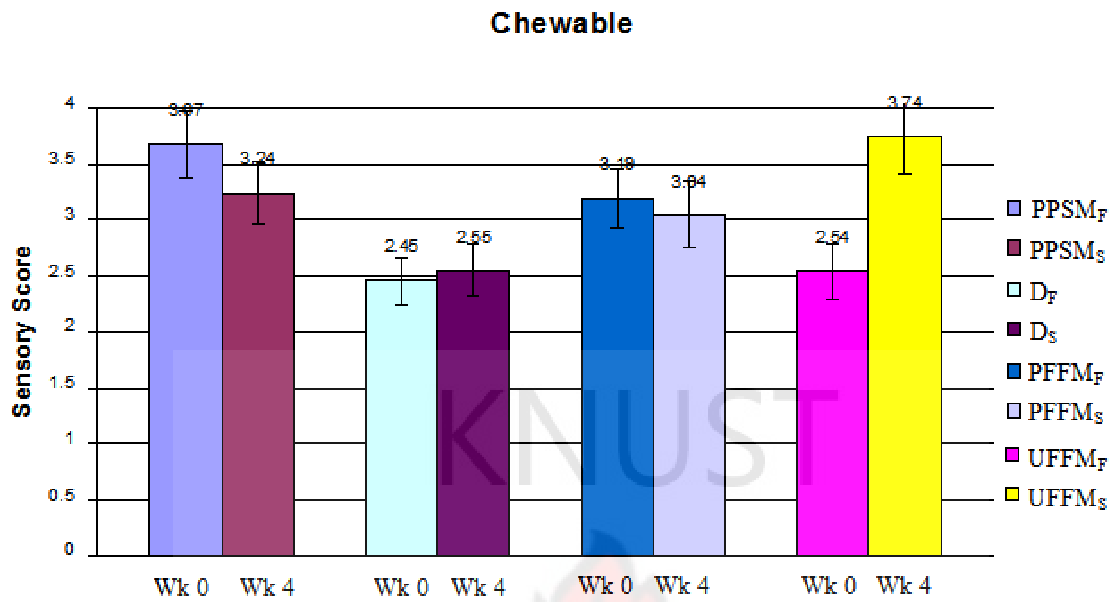


Figure 4.6: Comparison of 'Chewable' mean score of fried fresh (week zero) and stored (week four) Wagashie samples. [0= Chewable, 10= Not chewable].

[The error bars indicate Significant difference or otherwise at 5% confidence level (n=30; 10 panelists with three replications)].

No observable significant differences (P> 0.05) were shown by the Wagashie samples in both the fresh and the stored forms except sample UFFM. Sample $UFFM_S$ became less chewable than $UFFM_F$. However, all the samples (in both the fresh and the stored) had mean scores less than 5 indicating that the samples were perceived by the panel as chewable. This implies that the storage condition and time did not adversely affect the chewable texture of the Wagashie samples.

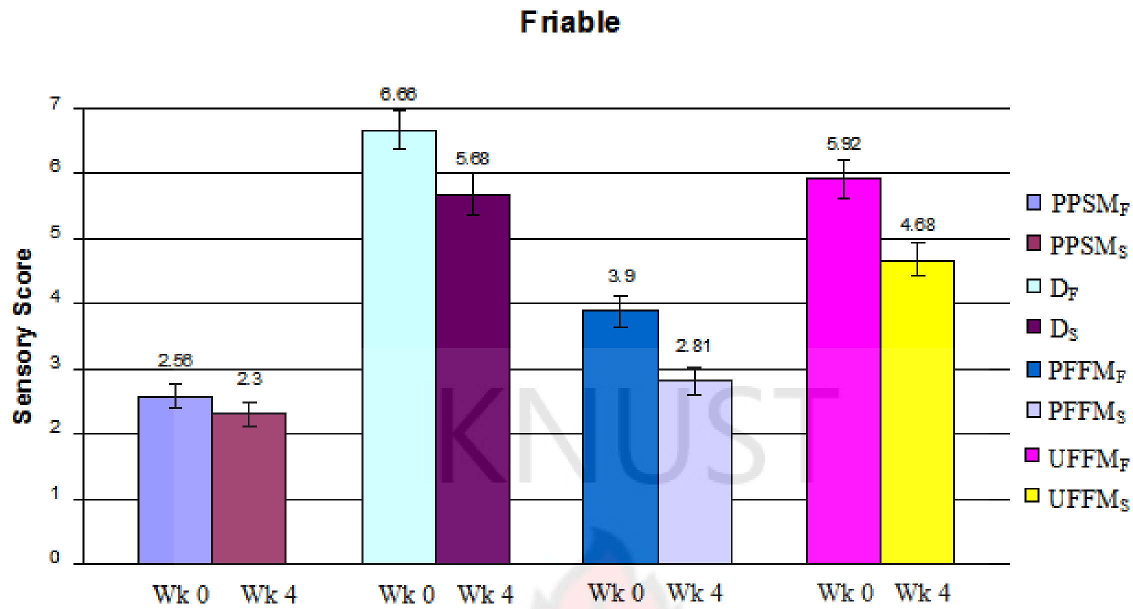


Figure 4.7: Comparison of 'Friable' mean score of fried fresh (week zero) and stored (week four) Wagashie samples. [0= Friable, 10= Not friable].

[The error bars indicate Significant difference or otherwise at 5% confidence level (n=30; 10 panelists with three replications)].

The friability of all the Wagashie samples increased significantly (P< 0.05) after storage except for sample PPSM. All the samples after storage were perceived to be friable (since their mean scores were less than 5) except sample D.

AROMA

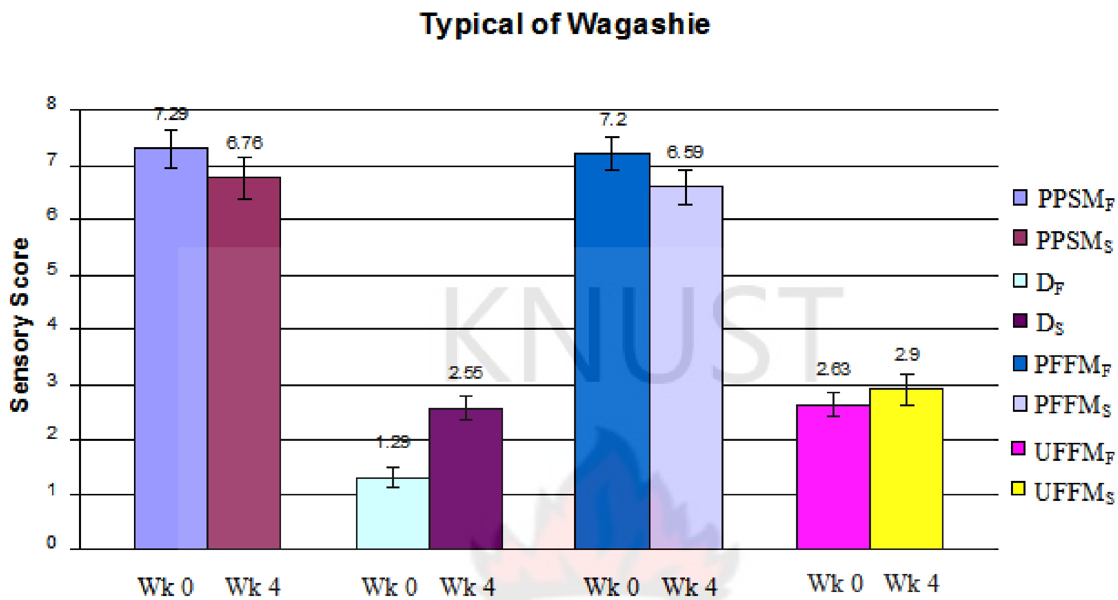


Figure 4.8: Comparison of 'Typical of Wagashie' mean score of fried fresh (week zero) and stored (week four) Wagashie samples. [0= Typical of Wagashie, 10= Not typical of Wagashie].

[The error bars indicate Significant difference or otherwise at 5% confidence level (n=30; 10 panelists with three replications)].

The aroma of all the Wagashie samples did not change significantly (P> 0.05) except sample D after storage. However, this significant change in D_S did not adversely affect its aroma since it remained in the 'typical of Wagashie' region (because the mean score was less than 5). $UFFM_S$ was also perceived as having a 'typical Wagashie' aroma. The aroma of $PPSM_S$ and $PFFM_S$ remained in the 'not typical of Wagashie' region (because their mean scores were greater than 5). Even though the free fatty acids of all the samples (Table 4) increased after storage, the threshold required to alter the aroma of the cheeses was not reached. Tejade *et al*. (2007) reported an increase in the odour intensity of cheese prepared with vegetable rennet after ninety days of ripening. This result is inconsistent with the current research due to the difference in the duration of ripening; in the case of the current research ripening lasted for only thirty days.

TASTE

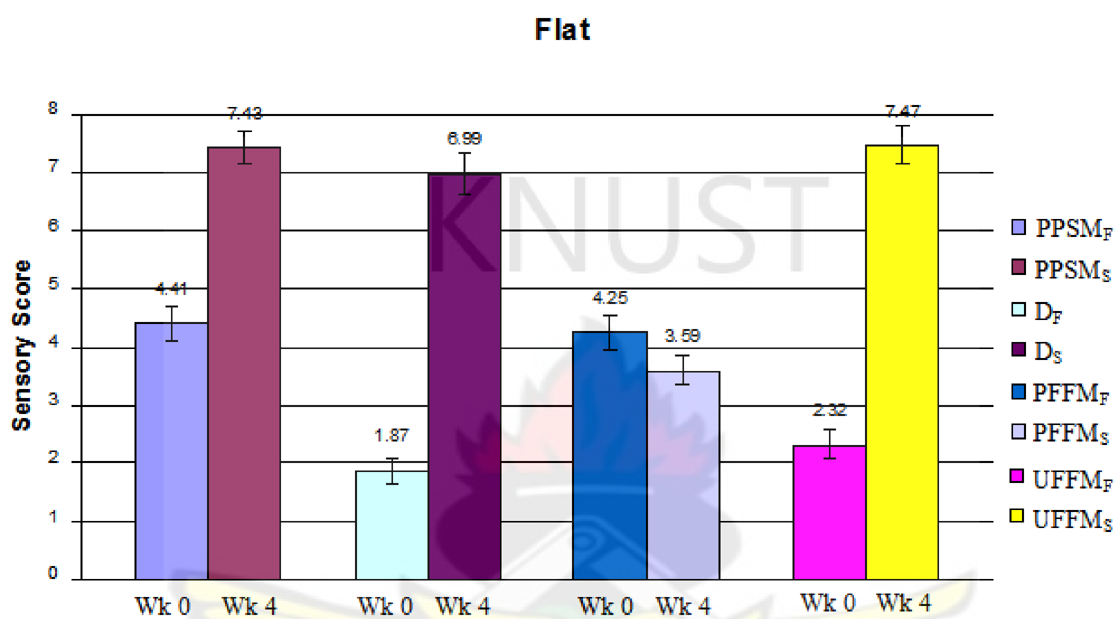


Figure 4.9: Comparison of 'Flat' mean score of fried fresh (week zero) and stored (week four) Wagashie samples. [0= Flat, 10= Not flat].

[The error bars indicate Significant difference or otherwise at 5% confidence level (n=30; 10 panelists with three replications)].

The average sensory score for flat ranged from about 1 to 8 (figure 4.9) indicating that the panel perceived a change in the taste of the samples. After storage all the samples changed significantly ($P < 0.05$), they lost their flatness (became bitter) except sample $PFFM_S$ (3.59) which became flatter. The loss of flatness by $PPSM_S$, D_S and $UFFM_S$ samples may be due to the excessive proteolysis caused by the residual Calotropin in the Wagashie samples during storage imparting bitter taste to the products (O' Connor, 1993). Tajeda *et al*. (2007) also reported bitter sensation in cheeses coagulated with plant coagulant enzyme and they attributed this transformation to an increase in taste-related compounds. Carmona *et al*.

(1999) reported a positive correlation between taste intensity and nitrogen fractions (soluble nitrogen, non-protein nitrogen, amino acid nitrogen, ammonia nitrogen) in cheeses during ripening.

Sample $PFFM_S$ remained flat due to the masking of the bitter sensation by its high fat content (Sousa *et al*., 2001).

4.5 Changes in the chemical composition of Wagashie samples during storage

Table 4.3: Chemical test values (wet basis) from week zero to week four for the four Wagashie types

Samples	Storage time (week)	% Moisture	% Protein	% Fat	% 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 derivation 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.

Moisture

Generally, the percentage moisture of all the Wagashie samples decreased significantly ($P < 0.05$) from week zero to week four (Table 4.3). This 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 ^{o}C for 17 days. The difference may result from the method of production of the two types of cheeses.

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 percentage moisture of PPSM and D after the storage period (Table 4.3). 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 hours, the moisture content was higher after the storage period contributing to its softness.

Protein

The method used for the measurement of percentage 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 4). Reduction in the moisture content of all the Wagashie samples after the first week of storage may have accounted for the increase in the percentage 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 % protein of Wagashie sample 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 4.3). Sample UFFM showed consistent significant decrease (P< 0.05) from week one to week four. Sample PFFM also showed a decrease in its % protein from week one to week four. The decreases observed at some points during the storage time (week two for sample PFFM, week four for samples 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 % 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 ^{o}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 4.3 shows that the percentage fat at the end of the storage period was significantly higher (P< 0.05) in sample PPSM (42.27%) and D (36.63%) than at the beginning of storage (PPSM, 40.995%; D, 31.41%). Sample UFFM showed consistent and significant decrease (P< 0.05) in its percentage fat from week zero to week two and increase

(P< 0.05) from week two to four. However, the percentage 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 % fat over a narrow range (31.41%- 43.47%). This indicates that fat breakdown (lypolysis) was very minimal due to the packaging technique adopted and the storage temperature (12 ^{o}C). 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 the storage temperature slowed the proliferation of the microbes. These lead to reduced perceivable breakdown of the fat. 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 ^{o}C for 17 days. Appiah's (2000) results on percentage fat showed a consistent decrease, this 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 percentage moisture and protein of the Wagashie samples (present study) may have effected the changes observed in the percentage fat of the samples.

FFA

The percentage free fatty acids of all the Wagashie samples at the end of the storage period showed significant (P< 0.05) increases (Table 4). Percentage change in FFA of all the Wagashie samples from week one to week two was insignificant (P> 0.05) except sample PFFM which showed a significant (P< 0.05) increase. The percentage FFA was highest in

Wagashie sample D (1.9%) and lowest in sample PFFM (1.025%) after the fourth week even though sample PFFM had the highest percentage fat. The percentage free fatty acid ranged from 0.67% to 1.9 % for the Wagashie samples 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 sample D package may have encouraged the influx of oxygen leading to oxidation. This may have contributed to the relatively high percentage FFA recorded in sample 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.

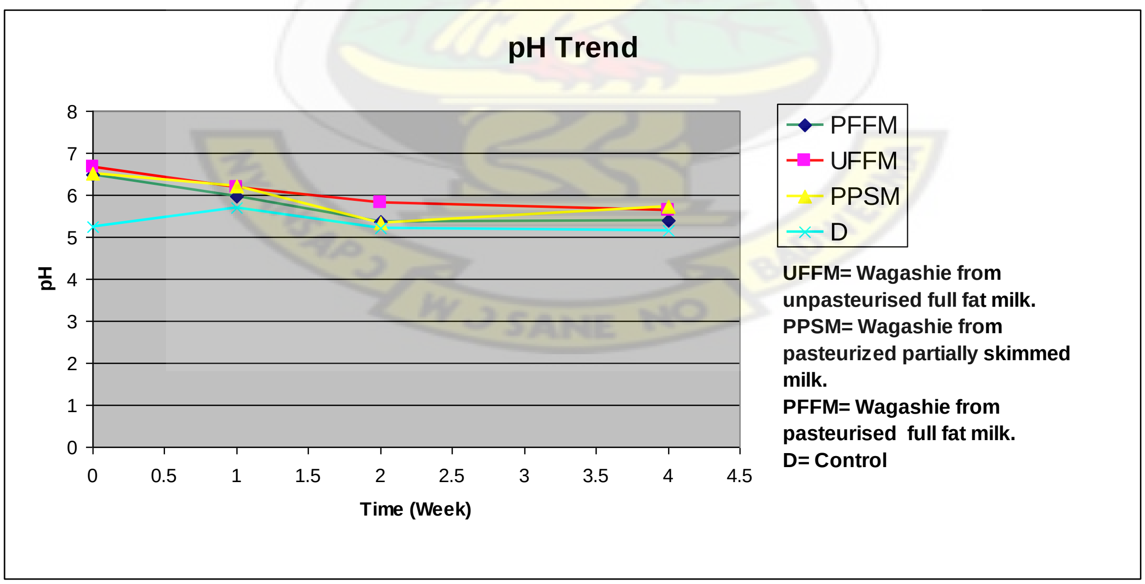


Figure 4.10 shows the change in pH from the beginning of storage (week zero) to the end of storage (week four).

pH

The pH of all the Wagashie samples decreased at the end of the storage period (figure 4.10). Sample UFFM showed a gradual decrease from the beginning to the end of storage. Sample PFFM and PPSM showed gradual decrease from the beginning to the second week of storage and increased slightly from week two to week four. 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 4.10) from the beginning of storage to the end was about one unit (6.67-5.2) 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. The decrease in the pH of the Wagashie samples 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. Sample D showed an increase in pH after week one and then gradually decrease to the end of the storage period. The rise after one week of storage 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).

4.6 Relationship between Sensory attributes and Chemical parameters

Table 4.4: ***Summary of Pearson Correlation Analysis of Sensory Attributes and Chemical Parameters***

Negative correlation	Positive correlation
Rough and Fat - Soggy and Fat -- Friable and Fat -	Compact and Fat + Typical Wagashie aroma and Fat ++ Flat and FFA ++

-/-- show negative correlation at 0.05/0.01 significance level
+/++ show positive correlation at 0.05/0.01 significance level

Changes in the chemical parameters of Wagashie during storage affected the perception of some of the sensory attributes studied. Fat correlated negatively with attributes rough, soggy and friable and positively with compact and typical Wagashie aroma (Table 4.4). This means that increase in percentage fat leads to a decrease in the sensory score of the attributes for negative correlation. For positive correlation, increase in percentage fat leads to an increase in the sensory score of the attributes.

Comparison of the percentage fat values of week one and four samples showed that percentage fat increased for sample PPSM and D but decreased for UFFM and PFFM at the end of storage. Even though fat showed negative correlation with the attribute rough, the panel recognized no significant change between week one and four Wagashie samples (figure 4.2). Again, negative correlation between fat and soggy did not affect the perception of the Wagashie samples in terms of attribute soggy since all the samples were perceived as soggy (figure 4.5). With regard to friability, the change in the fat content of week one and four for PPSM, PFFM and D samples did not change the panel's perception about the products since there were no transitions from one half of the graph to the other. However, the reduction in the percentage fat of sample UFFM caused a reduction in the sensory score (increase in friability) as shown by its transition from the second half to the first half of the graph (figure 4.7). Although fat correlated positively with compact and typical of Wagashie attributes, change in the percentage fat after storage did not drastically alter the panel's perception of the samples with respect to these attributes since the attributes were maintained in their respective halves.

The liberation of FFA after storage was not high for all the Wagashie samples. However, samples UFFM, PPSM and D recorded high FFA values relative to PFFM (Table 4.3). Sensory attribute Flat and FFA showed positive correlations indicating that high FFA value led to a high sensory score for attribute Flat (that is less flat). PFFM with low FFA value had low sensory score indicating that the taste was perceived as 'flat'. The rest on the other hand had relatively high FFA values indicating that their taste was perceived as 'Not flat' as shown by their transition from the first half of the graph to the second. Tajeda *et al*. (2007) observed no strong correlation between taste and free fatty acids in vegetable-extract coagulated cheese. However, a positive correlation ($P < 0.01$) observed in the current research, indicates that Wagashie is significantly affected by FFA. Increase in the percentage FFA of the cheeses prompted a higher sensory score for taste resulting in the change of the taste of the cheeses, except PFFM, from flat to less flat at the end of storage.

Correlation analysis showed that fat influenced textural (rough, soggy, friable and compact) and aroma (typical of Wagashie) attributes of Wagashie. However, the change in percentage fat of all the samples after four weeks of storage had little effect on the sensory attributes except the friability of sample UFFM. Percentage FFA increase after storage altered the taste of all the samples except PFFM.

4.7 CONCLUSION

A total of twenty attributes were generated by the panel to describe the sensory properties of cooked and fried Wagashie. References and definitions were provided for the generated attributes; these served as a guide during the sensory evaluation. Most of the attributes generated fell under colour, appearance and texture modalities. The following were the attributes agreed upon by the panel: Colour- broken-white, creamy and golden brown; Appearance- open, rough surface, compact; Texture- springy, firm, soggy, chewable and friable; Aroma and Taste- typical of Wagashie and flat respectively.

Chemical and sensory changes occurred in all the Wagashie samples during the four week storage period. Even though significant sensory changes occurred in the Wagashie samples with regard to some attributes the panel perceived them as having sensory characteristics similar to their fresh forms. The samples which fell under this category were $PPSM_S$ for golden brown, soft and soggy attribute; $UFFM_S$ for compact, chewable, soft and soggy attribute; $PFFM_S$ for attribute soft, compact, friable and flat attribute; and D_S for friable and typical of Wagashie attribute. All the Wagashie samples lost their taste after four weeks of storage except PFFM; the panel indicated that these samples developed bitter taste. Chemically significant changes occurred in the Wagashie samples after the storage period. However, comparison of the percentage protein between week zero and four were not significant for samples PPSM and PFFM. Of all the Wagashie samples D experienced the greatest change and PFFM the least change with regard to the chemical parameters.

Correlation analysis between the sensory attributes and chemical parameters showed that fat influenced textural (rough, soggy, friable and compact) and aroma (typical of Wagashie) attributes of Wagashie. However, the change in percentage fat of all the samples after four weeks of storage had little effect on the sensory attributes except the friability of sample UFFM. Increase in percentage FFA after storage altered the taste of all the samples except PFFM.

4.8 RECOMMENDATION

This research confirmed the observation of O'Connor (1993) that residual coagulant from Sodom apple gives rise to bitter taste in Wagashie during proteolysis. Studies should be conducted to determine amino acids changes and their relation to bitter taste development during ripening, and possible solutions to mitigate or eliminate this sensation.

It was observed that water from the Wagashie samples especially D dripped into the plastic package compromising the pack's preservative ability. Gums may be applied to reduce this dripping effect. Consumer acceptance may also be carried out to determine consumers' perception of Wagashie added gum.

After four weeks of storage sample PFFM maintained its stability regarding taste, consumer sensory evaluation should be conducted to determine its acceptance by consumers.

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APPENDIX

A.

Product Attitude Survey (PAS) form

NAME OF SUBJECT:
GENDER:
AGE:
OCCUPATION:

1. WHICH PART (REGION) OF GHANA DO YOU COME FROM?
2. WHICH PART OF GHANA DO YOU RESIDE?
3. HAVE YOU HEARD OF WAGASHIE BEFORE?
4. IF YES HOW DID YOU HEAR OF THIS PRODUCT
5. HAVE YOU CONSUMED THIS PRODUCT BEFORE?
6. IF YES HOW OFTEN DO YOU TAKE THIS PRODUCT: a. OCCASIONALLY b. FREQUENTLY.
7. DO YOU LIKE OR DISLIKE THIS PRODUCT?
8. ARE YOU ALLEGIC TO MILK OR MILK PRODUCTS?
9. WOULD YOU HAVE TIME TO SPARE FOR THIS EXERCISE?

B

SENSORY EVALUATION FORM

NAME SEX AGE

PRODUCT CODE

INSTRUCTION:

Before you are samples of Wagashie, please evaluate them based on the following attributes by making a mark on the horizontal line. Please do not give any score beside the horizontal line.

Bipolar anchors from 0cm to 10cm

Colour

Golden brown ________________________________ Not golden brown

Appearance

Rough ________________________________ Smooth

Compact ________________________________ Not compact

Texture-

Hand feel

Soft ________________________________ Hard

Soggy ________________________________ Not Soggy

Mouth feel

Chewable ________________________________ Not chewable

Friable ________________________________ Not friable

Aroma

Typical of wagashie ________________________________ Not typical

Taste

Flat ________________________________ Not flat

ANY COMMENT?

C (1) Statistical description of data on the sensory comparison of the fresh (zero week old) Wagashie samples

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Min	Max
ATTRIBUTE						Lower Bound	Upper Bound		
Colour	PFFM	30	2.533333	1.27207	0.232247	2.058335	3.008332	0.4	5.3
	UFFM	30	2.2	1.369118	0.249966	1.688763	2.711237	0.1	4.9
	PPSM	30	2.096667	1.096855	0.200257	1.687094	2.506239	0.2	4.7
	D		2.543333	1.530311	0.279395	1.971906	3.114761	0.4	5.3
	Total	120	2.343333	1.324668	0.120925	2.10389	2.582777	0.1	5.3
Rough (Appearance)	PFFM	30	2.246667	1.085876	0.198253	1.841194	2.652139	0.6	4.3
	UFFM	30	5.993333	1.564682	0.285671	5.409071	6.577595	3.9	9.8
	PPSM	30	2.62	1.428382	0.260786	2.086633	3.153367	0.3	5.1
	D	30	6.96	1.054252	0.192479	6.566336	7.353664	5.2	9.1
	Total	120	4.455	2.430819	0.221902	4.015611	4.894389	0.3	9.8
Compact (Appearance)	PFFM	30	8.233333	1.222302	0.223161	7.776918	8.689749	5.8	10
	UFFM	30	3.193333	1.566224	0.285952	2.608496	3.778171	0.6	6.1
	PPSM	30	6.586667	1.188083	0.216913	6.143029	7.030304	4.2	9.4
	D	30	1.983333	0.906331	0.165473	1.644904	2.321763	0.5	3.6
	Total	120	4.999167	2.809513	0.256472	4.491326	5.507007	0.5	10
Soft Texture (Hand-feel)	PFFM	30	4.23	1.354724	0.247338	3.724138	4.735862	1.4	6.5
	UFFM	30	2.203333	1.08166	0.197483	1.799435	2.607232	0.2	4.1
	PPSM	30	6.443333	1.53526	0.280299	5.870058	7.016609	4.2	9.7
	D	30	2.286667	1.255535	0.229228	1.817842	2.755491	0.2	5.2
	Total	120	3.790833	2.172324	0.198305	3.398169	4.183497	0.2	9.7
Soggy Texture (Hand-feel)	PFFM	30	1.96	1.001241	0.182801	1.586131	2.333869	0.4	4.1
	UFFM	30	3.303333	1.282907	0.234226	2.824288	3.782379	1	5.4
	PPSM	30	1.983333	1.234583	0.225403	1.522332	2.444334	0.2	4.9
	D	30	4.883333	1.379926	0.251939	4.368061	5.398606	2	7.8
	Total	120	3.0325	1.711855	0.15627	2.723069	3.341931	0.2	7.8

Continuation of table C (1)

Chewable Texture (Mouth-feel)	PFFM	30	3.19	1.435594	0.262102	2.65394	3.72606	0.1	5.2
	UFFM	30	2.536667	1.358367	0.248003	2.029444	3.043889	0.1	4.9
	PPSM	30	3.673333	1.667733	0.304485	3.050592	4.296075	0.9	6.4
	D	30	2.446667	1.193584	0.217918	2.000975	2.892358	0.2	4.6
	Total	120	2.961667	1.493357	0.136324	2.691731	3.231602	0.1	6.4
Friable Texture (Mouth-feel)	PFFM	30	3.9	1.300928	0.237516	3.414225	4.385775	1.6	6.6
	UFFM	30	5.92	1.694698	0.309408	5.28719	6.55281	2.7	9.6
	PPSM	30	2.563333	0.9929	0.181278	2.192578	2.934088	1	4.9
	D	30	6.66	1.658541	0.302807	6.040691	7.279309	3.6	9.8
	Total	120	4.760833	2.162215	0.197382	4.369997	5.15167	1	9.8
Aroma (Typical of Wagashie)	PFFM	30	7.2	1.643378	0.300038	6.586353	7.813647	3.9	10
	UFFM	30	2.63	1.2032	0.219673	2.180718	3.079282	0.7	5.2
	PPSM	30	7.29	1.877333	0.342753	6.588992	7.991008	3.1	10
	D	30	1.286667	0.968729	0.176865	0.924937	1.648396	0	4.6
	Total	120	4.601667	3.061525	0.279478	4.048273	5.155061	0	10
Flat (Taste)	PFFM	30	4.246667	1.565079	0.285743	3.662257	4.831077	1.5	7.3
	UFFM	30	2.323333	1.361967	0.24866	1.814767	2.8319	0.3	5.1
	PPSM	30	4.41	1.547267	0.282491	3.832241	4.987759	1.3	7.1
	D	30	1.866667	1.156193	0.211091	1.434937	2.298396	0.4	4.8
	Total	120	3.211667	1.801455	0.16445	2.88604	3.537293	0.3	7.3

C(2)

ANOVA for sensory comparison of the fresh (zero week old) Wagashie samples

		Sum of Squares	df	Mean Square	F	Sig.
Colour	Between Groups	4.724667	3	1.574889	0.89513	0.44601
	Within Groups	204.09	116	1.759397		
	Total	208.8147	119			
Rough (Appearance)	Between Groups	506.5637	3	168.8546	99.6327	5.82E-32
	Within Groups	196.5933	116	1.69477		
	Total	703.157	119			
Compact (Appearance)	Between Groups	760.0883	3	253.3628	163.987	1.46E-41
	Within Groups	179.2217	116	1.545014		
	Total	939.3099	119			
Soft Texture (Hand-feel)	Between Groups	360.3389	3	120.113	69.2428	9.79E-26
	Within Groups	201.221	116	1.734664		
	Total	561.5599	119			
Soggy Texture (Hand-feel)	Between Groups	172.4983	3	57.49942	37.849	3.94E-17
	Within Groups	176.225	116	1.519181		
	Total	348.7233	119			
Chewable Texture (Mouth-feel)	Between Groups	30.13367	3	10.04456	4.9529	0.00285
	Within Groups	235.25	116	2.028017		
	Total	265.3837	119			
Friable Texture (Mouth-feel)	Between Groups	315.6163	3	105.2054	50.6952	5.19E-21
	Within Groups	240.7297	116	2.075256		
	Total	556.3459	119			
Aroma (Typical of Wagashie)	Between Groups	865.655	3	288.5517	134.036	1.53E-37
	Within Groups	249.7247	116	2.152799		
	Total	1115.38	119			
Flat (Taste)	Between Groups	153.1617	3	51.05389	25.415	1.04E-12
	Within Groups	233.022	116	2.00881		
	Total	386.1837	119			

C (3)

LSD of the data on the sensory comparison of the fresh (zero week old) Wagashie samples

(Multiple Comparisons)

Dependent Variable	(I) Wagashie Types	(J) Wagashie Types	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Colour	PFFM	UFFM	0.33333	0.34248	0.332	-0.345	1.0117
		PPSM	0.43667	0.34248	0.205	-0.2417	1.115
		D	-0.01	0.34248	0.977	-0.6883	0.6683
	UFFM	PFFM	-0.33333	0.34248	0.332	-1.0117	0.345
		PPSM	0.10333	0.34248	0.763	-0.575	0.7817
		D	-0.34333	0.34248	0.318	-1.0217	0.335
	PPSM	PFFM	-0.43667	0.34248	0.205	-1.115	0.2417
		UFFM	-0.10333	0.34248	0.763	-0.7817	0.575
		D	-0.44667	0.34248	0.195	-1.125	0.2317
	D	PFFM	0.01	0.34248	0.977	-0.6683	0.6883
		UFFM	0.34333	0.34248	0.318	-0.335	1.0217
		PPSM	0.44667	0.34248	0.195	-0.2317	1.125
Rough (Appearance)	PFFM	UFFM	-3.74667*	0.33613	0	-4.4124	-3.0809
		PPSM	-0.37333	0.33613	0.269	-1.0391	0.2924
		D	-4.71333*	0.33613	0	-5.3791	-4.0476
	UFFM	PFFM	3.74667*	0.33613	0	3.0809	4.4124
		PPSM	3.37333*	0.33613	0	2.7076	4.0391
		D	-.96667*	0.33613	0.005	-1.6324	-0.3009
	PPSM	PFFM	0.37333	0.33613	0.269	-0.2924	1.0391
		UFFM	-3.37333*	0.33613	0	-4.0391	-2.7076
		D	-4.34000*	0.33613	0	-5.0058	-3.6742
	D	PFFM	4.71333*	0.33613	0	4.0476	5.3791
		UFFM	.96667*	0.33613	0.005	0.3009	1.6324
		PPSM	4.34000*	0.33613	0	3.6742	5.0058
Compact (Appearance)	PFFM	UFFM	5.04000*	0.32094	0	4.4043	5.6757
		PPSM	1.64667*	0.32094	0	1.011	2.2823
		D	6.25000*	0.32094	0	5.6143	6.8857
	UFFM	PFFM	-5.04000*	0.32094	0	-5.6757	-4.4043
		PPSM	-3.39333*	0.32094	0	-4.029	-2.7577
		D	1.21000*	0.32094	0	0.5743	1.8457
	PPSM	PFFM	-1.64667*	0.32094	0	-2.2823	-1.011
		UFFM	3.39333*	0.32094	0	2.7577	4.029
		D	4.60333*	0.32094	0	3.9677	5.239
	D	PFFM	-6.25000*	0.32094	0	-6.8857	-5.6143
		UFFM	-1.21000*	0.32094	0	-1.8457	-0.5743
		PPSM	-4.60333*	0.32094	0	-5.239	-3.9677

Continuation of C (3)

Soft Texture (Handfeel)	PFFM	UFFM	2.02667*	0.34007	0	1.3531	2.7002
		PPSM	-2.21333*	0.34007	0	-2.8869	-1.5398
		D	1.94333*	0.34007	0	1.2698	2.6169
	UFFM	PFFM	-2.02667*	0.34007	0	-2.7002	-1.3531
		PPSM	-4.24000*	0.34007	0	-4.9135	-3.5665
		D	-0.08333	0.34007	0.807	-0.7569	0.5902
	PPSM	PFFM	2.21333*	0.34007	0	1.5398	2.8869
		UFFM	4.24000*	0.34007	0	3.5665	4.9135
		D	4.15667*	0.34007	0	3.4831	4.8302
	D	PFFM	-1.94333*	0.34007	0	-2.6169	-1.2698
		UFFM	0.08333	0.34007	0.807	-0.5902	0.7569
		PPSM	-4.15667*	0.34007	0	-4.8302	-3.4831
Soggy Texture (Handfeel)	PFFM	UFFM	-1.34333*	0.31824	0	-1.9737	-0.713
		PPSM	-0.02333	0.31824	0.942	-0.6537	0.607
		D	-2.92333*	0.31824	0	-3.5537	-2.293
	UFFM	PFFM	1.34333*	0.31824	0	0.713	1.9737
		PPSM	1.32000*	0.31824	0	0.6897	1.9503
		D	-1.58000*	0.31824	0	-2.2103	-0.9497
	PPSM	PFFM	0.02333	0.31824	0.942	-0.607	0.6537
		UFFM	-1.32000*	0.31824	0	-1.9503	-0.6897
		D	-2.90000*	0.31824	0	-3.5303	-2.2697
	D	PFFM	2.92333*	0.31824	0	2.293	3.5537
		UFFM	1.58000*	0.31824	0	0.9497	2.2103
		PPSM	2.90000*	0.31824	0	2.2697	3.5303
Chewable Texture (Mouthfeel)	PFFM	UFFM	0.65333	0.3677	0.078	-0.0749	1.3816
		PPSM	-0.48333	0.3677	0.191	-1.2116	0.2449
		D	.74333*	0.3677	0.046	0.0151	1.4716
	UFFM	PFFM	-0.65333	0.3677	0.078	-1.3816	0.0749
		PPSM	-1.13667*	0.3677	0.002	-1.8649	-0.4084
		D	0.09	0.3677	0.807	-0.6383	0.8183
	PPSM	PFFM	0.48333	0.3677	0.191	-0.2449	1.2116
		UFFM	1.13667*	0.3677	0.002	0.4084	1.8649
		D	1.22667*	0.3677	0.001	0.4984	1.9549
	D	PFFM	-.74333*	0.3677	0.046	-1.4716	-0.0151
		UFFM	-0.09	0.3677	0.807	-0.8183	0.6383
		PPSM	-1.22667*	0.3677	0.001	-1.9549	-0.4984

Continuation of C (3)

Friable Texture (Mouthfeel)	PFFM	UFFM	-2.02000*	0.37195	0	-2.7567	-1.2833
		PPSM	1.33667*	0.37195	0	0.6	2.0734
		D	-2.76000*	0.37195	0	-3.4967	-2.0233
	UFFM	PFFM	2.02000*	0.37195	0	1.2833	2.7567
		PPSM	3.35667*	0.37195	0	2.62	4.0934
		D	-.74000*	0.37195	0.049	-1.4767	-0.0033
	PPSM	PFFM	-1.33667*	0.37195	0	-2.0734	-0.6
		UFFM	-3.35667*	0.37195	0	-4.0934	-2.62
		D	-4.09667*	0.37195	0	-4.8334	-3.36
	D	PFFM	2.76000*	0.37195	0	2.0233	3.4967
		UFFM	.74000*	0.37195	0.049	0.0033	1.4767
		PPSM	4.09667*	0.37195	0	3.36	4.8334
Flavour (Typical of Wagashie)	PFFM	UFFM	4.57000*	0.37884	0	3.8197	5.3203
		PPSM	-0.09	0.37884	0.813	-0.8403	0.6603
		D	5.91333*	0.37884	0	5.163	6.6637
	UFFM	PFFM	-4.57000*	0.37884	0	-5.3203	-3.8197
		PPSM	-4.66000*	0.37884	0	-5.4103	-3.9097
		D	1.34333*	0.37884	0.001	0.593	2.0937
	PPSM	PFFM	0.09	0.37884	0.813	-0.6603	0.8403
		UFFM	4.66000*	0.37884	0	3.9097	5.4103
		D	6.00333*	0.37884	0	5.253	6.7537
	D	PFFM	-5.91333*	0.37884	0	-6.6637	-5.163
		UFFM	-1.34333*	0.37884	0.001	-2.0937	-0.593
		PPSM	-6.00333*	0.37884	0	-6.7537	-5.253
Flat (Taste)	PFFM	UFFM	1.92333*	0.36595	0	1.1985	2.6481
		PPSM	-0.16333	0.36595	0.656	-0.8881	0.5615
		D	2.38000*	0.36595	0	1.6552	3.1048
	UFFM	PFFM	-1.92333*	0.36595	0	-2.6481	-1.1985
		PPSM	-2.08667*	0.36595	0	-2.8115	-1.3619
		D	0.45667	0.36595	0.215	-0.2681	1.1815
	PPSM	PFFM	0.16333	0.36595	0.656	-0.5615	0.8881
		UFFM	2.08667*	0.36595	0	1.3619	2.8115
		D	2.54333*	0.36595	0	1.8185	3.2681
	D	PFFM	-2.38000*	0.36595	0	-3.1048	-1.6552
		UFFM	-0.45667	0.36595	0.215	-1.1815	0.2681
		PPSM	-2.54333*	0.36595	0	-3.2681	-1.8185

*. The mean difference is significant at the 0.05 level.

D(1) Statistical description of data on the sensory comparison of UFFM fresh and stored in their fried state

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Min	Max
						Lower Bound	Upper Bound		
Colour (Golden brown)	UFFM (Fried fresh)	30	2.2	1.369118	0.249966	1.688763	2.711237	0.1	4.9
	UFFM (Fried Stored)	30	2.37	1.162681	0.212276	1.935848	2.804152	0.2	5.2
	Total	60	2.285	1.262205	0.16295	1.958938	2.611062	0.1	5.2
Rough (Appearance)	UFFM (Fried fresh)		5.993333	1.564682	0.285671	5.409071	6.577595	3.9	9.8
	UFFM (Fried Stored)	30	6.22	1.236346	0.225725	5.758341	6.681659	4.7	9.2
	Total	60	6.106667	1.402766	0.181096	5.744294	6.469039	3.9	9.8
Compact (Appearance)	UFFM (Fried fresh)	30	3.193333	1.566224	0.285952	2.608496	3.778171	0.6	6.1
	UFFM (Fried Stored)	30	2.566667	1.188257	0.216945	2.122964	3.010369	0.6	5.2
	Total	60	2.88	1.41407	0.182556	2.514707	3.245293	0.6	6.1
Soft (Hand Feel)	UFFM (Fried fresh)	30	2.203333	1.08166	0.197483	1.799435	2.607232	0.2	4.1
	UFFM (Fried Stored)	30	1.77	0.918826	0.167754	1.426905	2.113095	0.3	3.4
	Total	60	1.986667	1.018717	0.131516	1.723504	2.249829	0.2	4.1
Soggy (Hand Feel)	UFFM (Fried fresh)	30	3.303333	1.282907	0.234226	2.824288	3.782379	1	5.4
	UFFM (Fried Stored)	30	3.996667	1.252166	0.228613	3.5291	4.464233	1	6.2
	Total	60	3.65	1.304555	0.168417	3.312998	3.987002	1	6.2
Chewable (Mouth Feel)	UFFM (Fried fresh)	30	2.536667	1.358367	0.248003	2.029444	3.043889	0.1	4.9
	UFFM (Fried Stored)	30	3.736667	1.779671	0.324922	3.072126	4.401207	0.3	8
	Total	60	3.136667	1.682207	0.217172	2.702107	3.571227	0.1	8
Friable (Mouth Feel)	UFFM (Fried fresh)	30	5.92	1.694698	0.309408	5.28719	6.55281	2.7	9.6
	UFFM (Fried Stored)	30	4.676667	1.335376	0.243805	4.178029	5.175304	2.3	7.3
	Total	60	5.298333	1.637432	0.211392	4.87534	5.721327	2.3	9.6
Aroma (Typical of Wagashie)	UFFM (Fried fresh)	30	2.63	1.2032	0.219673	2.180718	3.079282	0.7	5.2
	UFFM (Fried Stored)	30	2.896667	1.543056	0.281722	2.32048	3.472853	0.3	6.3
	Total	60	2.763333	1.378401	0.177951	2.407255	3.119412	0.3	6.3
Taste (Flat)	UFFM (Fried fresh)	30	2.323333	1.361967	0.24866	1.814767	2.8319	0.3	5.1
	UFFM (Fried Stored)	30	7.466667	1.81114	0.330668	6.790376	8.142958	3.6	10
	Total	60	4.895	3.041321	0.392633	4.109343	5.680657	0.3	10

D (2)

ANOVA for sensory comparison of UFFM fresh and stored in their fried state						
		Sum of Squares	df	Mean Square	F	Sig.
Colour (Golden brown)	Between Groups	0.4335	1	0.4335	0.2687	0.60616
	Within Groups	93.563	58	1.6132		
	Total	93.9965	59			
Rough (Appearance)	Between Groups	0.77067	1	0.7707	0.3876	0.53601
	Within Groups	115.327	58	1.9884		
	Total	116.097	59			
Compact (Appearance)	Between Groups	5.89067	1	5.8907	3.0482	0.08612
	Within Groups	112.085	58	1.9325		
	Total	117.976	59			
Soft (Hand Feel)	Between Groups	2.81667	1	2.8167	2.7968	0.09984
	Within Groups	58.4127	58	1.0071		
	Total	61.2293	59			
Soggy (Hand Feel)	Between Groups	7.21067	1	7.2107	4.4874	0.03844
	Within Groups	93.1993	58	1.6069		
	Total	100.41	59			
Chewable (Mouth Feel)	Between Groups	21.6	1	21.6	8.6186	0.00476
	Within Groups	145.359	58	2.5062		
	Total	166.959	59			
Friable (Mouth Feel)	Between Groups	23.1882	1	23.188	9.9622	0.00253
	Within Groups	135.002	58	2.3276		
	Total	158.19	59			
Aroma (Typical of Wagashie)	Between Groups	1.06667	1	1.0667	0.5572	0.45841
	Within Groups	111.033	58	1.9144		
	Total	112.099	59			
Taste (Flat)	Between Groups	396.808	1	396.81	154.54	5.35E-18
	Within Groups	148.92	58	2.5676		
	Total	545.729	59			

E (1) Statistical description of the data on the sensory comparison of PPSM fresh and stored in their fried state

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Min	Max
						Lower Bound	Upper Bound		
Colour (Goldenbrown)	PPSM (Fried fresh)	30	2.096667	1.096855	0.200257	1.687094	2.506239	0.2	4.7
	PPSM (Fried Stored)	30	2.933333	1.729926	0.31584	2.287368	3.579298	0.2	9.3
	Total	60	2.515	1.496756	0.19323	2.128347	2.901653	0.2	9.3
Rough (Appearance)	PPSM (Fried fresh)		2.62	1.428382	0.260786	2.086633	3.153367	0.3	5.1
	PPSM (Fried Stored)	30	2.84	1.190074	0.217277	2.395619	3.284381	0.3	4.9
	Total	60	2.73	1.308162	0.168883	2.392066	3.067934	0.3	5.1
Compact (Appearance)	PPSM (Fried fresh)	30	6.586667	1.188083	0.216913	6.143029	7.030304	4.2	9.4
	PPSM (Fried Stored)	30	6.583333	1.004501	0.183396	6.208246	6.95842	4.9	8.4
	Total	60	6.585	1.090766	0.140817	6.303225	6.866775	4.2	9.4
Soft (Hand Feel)	PPSM (Fried fresh)	30	6.443333	1.53526	0.280299	5.870058	7.016609	4.2	9.7
	PPSM (Fried Stored)	30	5.656667	1.260455	0.230127	5.186005	6.127328	2.8	8.8
	Total	60	6.05	1.448026	0.186939	5.675935	6.424065	2.8	9.7
Soggy (Hand Feel)	PPSM (Fried fresh)	30	1.983333	1.234583	0.225403	1.522332	2.444334	0.2	4.9
	PPSM (Fried Stored)	30	1.566667	0.830178	0.151569	1.256673	1.87666	0.4	3.4
	Total	60	1.775	1.063991	0.137361	1.500142	2.049858	0.2	4.9
Chewable (Mouth Feel)	PPSM (Fried fresh)	30	3.673333	1.667733	0.304485	3.050592	4.296075	0.9	6.4
	PPSM (Fried Stored)	30	3.243333	1.518321	0.277206	2.676383	3.810284	0.4	6.8
	Total	60	3.458333	1.596	0.206043	3.046043	3.870624	0.4	6.8
Friable (Mouth Feel)	PPSM (Fried fresh)	30	2.563333	0.9929	0.181278	2.192578	2.934088	1	4.9
	PPSM (Fried Stored)	30	2.296667	1.035069	0.188977	1.910166	2.683168	0.9	4.5
	Total	60	2.43	1.014522	0.130974	2.167921	2.692079	0.9	4.9
Aroma (Typical of Wagashie)	PPSM (Fried fresh)	30	7.29	1.877333	0.342753	6.588992	7.991008	3.1	10
	PPSM (Fried Stored)	30	6.763333	1.998186	0.364817	6.017198	7.509468	2.6	10
	Total	60	7.026667	1.940458	0.250512	6.525393	7.52794	2.6	10
Taste (Flat)	PPSM (Fried fresh)	30	4.41	1.547267	0.282491	3.832241	4.987759	1.3	7.1
	PPSM (Fried Stored)	30	7.433333	1.550825	0.283141	6.854246	8.012421	4.7	10
	Total	60	5.921667	2.163965	0.279367	5.362655	6.480678	1.3	10

E (2)

ANOVA for sensory comparison of PPSM fresh and stored in their fried state						
		Sum of Squares	df	Mean Square	F	Sig.
Colour (Golden brown)	Between Groups	10.50017	1	10.50017	5.0052	0.029129
	Within Groups	121.6763	58	2.097868		
	Total	132.1765	59			
Rough (Appearance)	Between Groups	0.726	1	0.726	0.4201	0.519459
	Within Groups	100.24	58	1.728276		
	Total	100.966	59			
Compact (Appearance)	Between Groups	0.000167	1	0.000167	0.0001	0.990677
	Within Groups	70.19633	58	1.210282		
	Total	70.1965	59			
Soft (Hand Feel)	Between Groups	9.282667	1	9.282667	4.7051	0.034185
	Within Groups	114.4273	58	1.972885		
	Total	123.71	59			
Soggy (Hand Feel)	Between Groups	2.604167	1	2.604167	2.3531	0.130471
	Within Groups	64.18833	58	1.106695		
	Total	66.7925	59			
Chewable (Mouth Feel)	Between Groups	2.7735	1	2.7735	1.0905	0.300692
	Within Groups	147.5123	58	2.543316		
	Total	150.2858	59			
Friable (Mouth Feel)	Between Groups	1.066667	1	1.066667	1.037	0.31275
	Within Groups	59.65933	58	1.028609		
	Total	60.726	59			
Aroma (Typical of Wagashie)	Between Groups	4.160667	1	4.160667	1.107	0.297102
	Within Groups	217.9967	58	3.758563		
	Total	222.1573	59			
Taste (Flat)	Between Groups	137.1082	1	137.1082	57.139	3.37E-10
	Within Groups	139.1737	58	2.399546		
	Total	276.2818	59			

F (1) Statistical description of the data on the sensory comparison of PFFM fresh and stored in their fried state

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Min	Max
						Lower Bound	Upper Bound		
Colour (Golden brown)	PFFM (Fried fresh)	30	2.533333	1.27207	0.2322	2.058335	3.008332	0.4	5.3
	PFFM (Fried Stored)	30	2.23	1.280665	0.2338	1.751792	2.708208	0.3	4.8
	Total	60	2.381667	1.274721	0.1646	2.052371	2.710962	0.3	5.3
Rough (Appearance)	PFFM (Fried fresh)		2.246667	1.085876	0.1983	1.841194	2.652139	0.6	4.3
	PFFM (Fried Stored)	30	2.196667	1.061386	0.1938	1.800339	2.592995	0.2	4.4
	Total	60	2.221667	1.064861	0.1375	1.946584	2.496749	0.2	4.4
Compact (Appearance)	PFFM (Fried fresh)	30	8.233333	1.222302	0.2232	7.776918	8.689749	5.8	10
	PFFM (Fried Stored)	30	7.02	1.182166	0.2158	6.578572	7.461428	4.3	9.2
	Total	60	7.626667	1.339981	0.173	7.280513	7.97282	4.3	10
Soft (Hand Feel)	PFFM (Fried fresh)	30	4.23	1.354724	0.2473	3.724138	4.735862	1.4	6.5
	PFFM (Fried Stored)	30	3.323333	1.327867	0.2424	2.8275	3.819167	0.8	5.4
	Total	60	3.776667	1.406326	0.1816	3.413374	4.139959	0.8	6.5
Soggy (Hand Feel)	PFFM (Fried fresh)	30	1.96	1.001241	0.1828	1.586131	2.333869	0.4	4.1
	PFFM (Fried Stored)	30	2.293333	1.141968	0.2085	1.866915	2.719751	0.4	4.7
	Total	60	2.126667	1.077956	0.1392	1.848201	2.405132	0.4	4.7
Chewable (Mouth Feel)	PFFM (Fried fresh)	30	3.19	1.435594	0.2621	2.65394	3.72606	0.1	5.2
	PFFM (Fried Stored)	30	3.043333	1.600578	0.2922	2.445668	3.640999	0.4	5.7
	Total	60	3.116667	1.5092	0.1948	2.726799	3.506534	0.1	5.7
Friable (Mouth Feel)	PFFM (Fried fresh)	30	3.9	1.300928	0.2375	3.414225	4.385775	1.6	6.6
	PFFM (Fried Stored)	30	2.81	1.212677	0.2214	2.357179	3.262821	0.8	5.1
	Total	60	3.355	1.362628	0.1759	3.002996	3.707004	0.8	6.6
Aroma (Typical of Wagashie)	PFFM (Fried fresh)	30	7.2	1.643378	0.3	6.586353	7.813647	3.9	10
	PFFM (Fried Stored)	30	6.59	1.689797	0.3085	5.959019	7.220981	3.9	10
	Total	60	6.895	1.680943	0.217	6.460766	7.329234	3.9	10
Taste (Flat)	PFFM (Fried fresh)	30	4.246667	1.565079	0.2857	3.662257	4.831077	1.5	7.3
	PFFM (Fried Stored)	30	3.586667	1.34875	0.2462	3.083035	4.090298	1.1	6.8
	Total	60	3.916667	1.486227	0.1919	3.532734	4.3006	1.1	7.3

F (2)

ANOVA for sensory comparison of PFFM fresh and stored in their fried state						
		Sum of Squares	df	Mean Square	F	Sig.
Colour (Golden brown)	Between Groups	1.380167	1	1.380167	0.847179	0.36116
	Within Groups	94.48967	58	1.629132		
	Total	95.86983	59			
Rough (Appearance)	Between Groups	0.0375	1	0.0375	0.032529	0.8575
	Within Groups	66.86433	58	1.152833		
	Total	66.90183	59			
Compact (Appearance)	Between Groups	22.08267	1	22.08267	15.27398	0.00025
	Within Groups	83.85467	58	1.44577		
	Total	105.9373	59			
Soft (Hand Feel)	Between Groups	12.33067	1	12.33067	6.853215	0.01127
	Within Groups	104.3567	58	1.799253		
	Total	116.6873	59			
Soggy (Hand Feel)	Between Groups	1.666667	1	1.666667	1.445144	0.23419
	Within Groups	66.89067	58	1.153287		
	Total	68.55733	59			
Chewable (Mouth Feel)	Between Groups	0.322667	1	0.322667	0.139598	0.71004
	Within Groups	134.0607	58	2.311391		
	Total	134.3833	59			
Friable (Mouth Feel)	Between Groups	17.8215	1	17.8215	11.26873	0.0014
	Within Groups	91.727	58	1.5815		
	Total	109.5485	59			
Aroma (Typical of Wagashie)	Between Groups	5.5815	1	5.5815	2.009142	0.1617
	Within Groups	161.127	58	2.778052		
	Total	166.7085	59			
Taste (Flat)	Between Groups	6.534	1	6.534	3.061427	0.08546
	Within Groups	123.7893	58	2.134299		
	Total	130.3233	59			

G (1) Statistical description of the data on the sensory comparison of D fresh and stored in their fried state

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Min	Max
						Lower Bound	Upper Bound		
Colour (Golden brown)	D (Fried fresh)	30	2.543333	1.530311	0.279395	1.971906	3.114761	0.4	5.3
	D (Fried Stored)	30	2.166667	1.25515	0.229158	1.697986	2.635347	0.2	4.3
	Total	60	2.355	1.400536	0.180808	1.993203	2.716797	0.2	5.3
Rough (Appearance)	D (Fried fresh)		6.96	1.054252	0.192479	6.566336	7.353664	5.2	9.1
	D (Fried Stored)	30	6.933333	1.194624	0.218107	6.487253	7.379413	4.6	8.7
	Total	60	6.946667	1.117119	0.144219	6.658084	7.235249	4.6	9.1
Compact (Appearance)	D (Fried fresh)	30	1.983333	0.906331	0.165473	1.644904	2.321763	0.5	3.6
	D (Fried Stored)	30	1.926667	1.173833	0.214312	1.48835	2.364983	0.1	4.1
	Total	60	1.955	1.040115	0.134278	1.68631	2.22369	0.1	4.1
Soft (Hand Feel)	D (Fried fresh)	30	2.286667	1.255535	0.229228	1.817842	2.755491	0.2	5.2
	D (Fried Stored)	30	1.926667	1.235937	0.22565	1.46516	2.388173	0.4	5.1
	Total	60	2.106667	1.248439	0.161173	1.784161	2.429173	0.2	5.2
Soggy (Hand Feel)	D (Fried fresh)	30	4.883333	1.379926	0.251939	4.368061	5.398606	2	7.8
	D (Fried Stored)	30	4.326667	1.892623	0.345544	3.61995	5.033384	0.8	7.3
	Total	60	4.605	1.665953	0.215074	4.174639	5.035361	0.8	7.8
Chewable (Mouth Feel)	D (Fried fresh)	30	2.446667	1.193584	0.217918	2.000975	2.892358	0.2	4.6
	D (Fried Stored)	30	2.55	1.286736	0.234925	2.069525	3.030475	0.9	5.8
	Total	60	2.498333	1.231575	0.158996	2.180184	2.816483	0.2	5.8
Friable (Mouth Feel)	D (Fried fresh)	30	6.66	1.658541	0.302807	6.040691	7.279309	3.6	9.8
	D (Fried Stored)	30	5.683333	1.820209	0.332323	5.003656	6.363011	1.1	8.8
	Total	60	6.171667	1.795294	0.231772	5.707893	6.63544	1.1	9.8
Aroma (Typical of Wagashie)	D (Fried fresh)	30	1.286667	0.968729	0.176865	0.924937	1.648396	0	4.6
	D (Fried Stored)	30	2.55	1.162859	0.212308	2.115781	2.984219	0.6	5.6
	Total	60	1.918333	1.237615	0.159775	1.598623	2.238043	0	5.6
Taste (Flat)	D (Fried fresh)	30	1.866667	1.156193	0.211091	1.434937	2.298396	0.4	4.8
	D (Fried Stored)	30	6.986667	2.014556	0.367806	6.234419	7.738914	3.4	10
	Total	60	4.426667	3.052305	0.394051	3.638173	5.215161	0.4	10

G (2) ANOVA for sensory comparison of D fresh and stored in their fried state

		Sum of Squares	df	Mean Square	F	Sig.
Colour (Golden brown)	Between Groups	2.128167	1	2.128167	1.086561	0.30156
	Within Groups	113.6003	58	1.958626		
	Total	115.7285	59			
Rough (Appearance)	Between Groups	0.010667	1	0.010667	0.008404	0.927275
	Within Groups	73.61867	58	1.269287		
	Total	73.62933	59			
Compact (Appearance)	Between Groups	0.048167	1	0.048167	0.043801	0.834957
	Within Groups	63.78033	58	1.099661		
	Total	63.8285	59			
Soft (Hand Feel)	Between Groups	1.944	1	1.944	1.252614	0.267667
	Within Groups	90.01333	58	1.551954		
	Total	91.95733	59			
Soggy (Hand Feel)	Between Groups	4.648167	1	4.648167	1.694488	0.198157
	Within Groups	159.1003	58	2.743109		
	Total	163.7485	59			
Chewable (Mouth Feel)	Between Groups	0.160167	1	0.160167	0.103993	0.748249
	Within Groups	89.32967	58	1.540167		
	Total	89.48983	59			
Friable (Mouth Feel)	Between Groups	14.30817	1	14.30817	4.719115	0.033929
	Within Groups	175.8537	58	3.03196		
	Total	190.1618	59			
Aroma (Typical of Wagashie)	Between Groups	23.94017	1	23.94017	20.90225	2.58E-05
	Within Groups	66.42967	58	1.145339		
	Total	90.36983	59			
Taste (Flat)	Between Groups	393.216	1	393.216	145.7646	1.83E-17
	Within Groups	156.4613	58	2.697609		
	Total	549.6773	59			

H (1) Statistical description of the data gathered on chemical analysis conducted weekly on Wagashie sample UFFM

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Min	Max
						Lower Bound	Upper Bound		
Moisture	wk 0	2	47.35	0.014142	0.01	47.22294	47.47706	47.34	47.36
	wk1	2	45.755	0.106066	0.075	44.80203	46.70797	45.68	45.83
	wk2	2	45.975	0.176777	0.125	44.38672	47.56328	45.85	46.1
	wk 4		45.79	0	0	45.79	45.79	45.79	45.79
	Total	8	46.2175	0.708998	0.250669	45.62476	46.81024	45.68	47.36
Crude Protein	wk 0	2	20.63	0.268701	0.19	18.21582	23.04418	20.44	20.82
	wk1	2	22.035	0.007071	0.005	21.97147	22.09853	22.03	22.04
	wk2	2	21.64	0.014142	0.01	21.51294	21.76706	21.63	21.65
	wk 4	2	21.195	0.007071	0.005	21.13147	21.25853	21.19	21.2
	Total	8	21.375	0.568079	0.200846	20.90007	21.84993	20.44	22.04
Fat	wk 0	2	41.14	0.042426	0.03	40.75881	41.52119	41.11	41.17
	wk1	2	40.145	0.091924	0.065	39.3191	40.9709	40.08	40.21
	wk2	2	39.045	0.077782	0.055	38.34616	39.74384	38.99	39.1
	wk 4	2	39.525	0.233345	0.165	37.42848	41.62152	39.36	39.69
	Total	8	39.96375	0.84319	0.298113	39.25883	40.66867	38.99	41.17

H (2)

ANOVA for chemical analysis conducted weekly on Wagashie sample UFFM

		Sum of Squares	df	Mean Square	F	Sig.
Moisture	Between Groups	3.47605	3	1.158683	108.54	0.000275
	Within Groups	0.0427	4	0.010675		
	Total	3.51875	7			
Crude Protein	Between Groups	2.1865	3	0.728833	40.211	0.00191
	Within Groups	0.0725	4	0.018125		
	Total	2.259	7			
Fat	Between Groups	4.906038	3	1.635346	92.458	0.000377
	Within Groups	0.07075	4	0.017688		
	Total	4.976788	7			

H (3) LSD on data gathered on chemical analysis conducted weekly on Wagashie sample UFFM

(Multiple Comparisons)

Dependent Variable	(I) Wagashie(UFFM	(J) Wagashie(UFFM	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Moisture	wk 0	wk1	1.59500*	0.10332	0	1.3081	1.8819
		wk2	1.37500*	0.10332	0	1.0881	1.6619
		wk 4	1.56000*	0.10332	0	1.2731	1.8469
	wk1	wk 0	-1.59500*	0.10332	0	-1.8819	-1.3081
		wk2	-0.22	0.10332	0.1	-0.5069	0.0669
		wk 4	-0.035	0.10332	0.752	-0.3219	0.2519
	wk2	wk 0	-1.37500*	0.10332	0	-1.6619	-1.0881
		wk1	0.22	0.10332	0.1	-0.0669	0.5069
		wk 4	0.185	0.10332	0.148	-0.1019	0.4719
	wk 4	wk 0	-1.56000*	0.10332	0	-1.8469	-1.2731
		wk1	0.035	0.10332	0.752	-0.2519	0.3219
		wk2	-0.185	0.10332	0.148	-0.4719	0.1019
Crude Protein	wk 0	wk1	-1.40500*	0.13463	0	-1.7788	-1.0312
		wk2	-1.01000*	0.13463	0.002	-1.3838	-0.6362
		wk 4	-.56500*	0.13463	0.014	-0.9388	-0.1912
	wk1	wk 0	1.40500*	0.13463	0	1.0312	1.7788
		wk2	.39500*	0.13463	0.043	0.0212	0.7688
		wk 4	.84000*	0.13463	0.003	0.4662	1.2138
	wk2	wk 0	1.01000*	0.13463	0.002	0.6362	1.3838
		wk1	-.39500*	0.13463	0.043	-0.7688	-0.0212
		wk 4	.44500*	0.13463	0.03	0.0712	0.8188
	wk 4	wk 0	.56500*	0.13463	0.014	0.1912	0.9388
		wk1	-.84000*	0.13463	0.003	-1.2138	-0.4662
		wk2	-.44500*	0.13463	0.03	-0.8188	-0.0712

Continuation of table H (3)

Fat	wk 0	wk1	.99500*	0.13299	0.002	0.6257	1.3643
		wk2	2.09500*	0.13299	0	1.7257	2.4643
		wk 4	1.61500*	0.13299	0	1.2457	1.9843
	wk1	wk 0	-.99500*	0.13299	0.002	-1.3643	-0.6257
		wk2	1.10000*	0.13299	0.001	0.7307	1.4693
		wk 4	.62000*	0.13299	0.01	0.2507	0.9893
	wk2	wk 0	-2.09500*	0.13299	0	-2.4643	-1.7257
		wk1	-1.10000*	0.13299	0.001	-1.4693	-0.7307
		wk 4	-.48000*	0.13299	0.023	-0.8493	-0.1107
	wk 4	wk 0	-1.61500*	0.13299	0	-1.9843	-1.2457
		wk1	-.62000*	0.13299	0.01	-0.9893	-0.2507
		wk2	.48000*	0.13299	0.023	0.1107	0.8493

*. The mean difference is significant at the 0.05 level.

I (1) Statistical description of the data gathered on chemical analysis conducted weekly on Wagashie sample PPSM

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Min	Max
						Lower Bound	Upper Bound		
Moisture	wk 0	2	47.755	0.14849	0.11	46.42085	49.08915	47.65	47.86
	wk1	2	46.605	0.07778	0.06	45.90616	47.30384	46.55	46.66
	wk2	2	45.975	0.17678	0.13	44.38672	47.56328	45.85	46.1
	wk 4	2	46.87	0.04243	0.03	46.48881	47.25119	46.84	46.9
	Total	8	46.80125	0.68996	0.24	46.22443	47.37807	45.85	47.86
Crude Protein	wk 0	2	20.625	0.23335	0.17	18.52848	22.72152	20.46	20.79
	wk1	2	21.03	0.12728	0.09	19.88644	22.17356	20.94	21.12
	wk2	2	21.835	0.10607	0.08	20.88203	22.78797	21.76	21.91
	wk 4	2	20.89	0.25456	0.18	18.60288	23.17712	20.71	21.07
	Total	8	21.095	0.50373	0.18	20.67387	21.51613	20.46	21.91
Fat	wk 0	2	40.995	0.33234	0.24	38.00904	43.98096	40.76	41.23
	wk1	2	40.715	0.34648	0.25	37.60198	43.82802	40.47	40.96
	wk2	2	40.975	0.38891	0.28	37.48079	44.46921	40.7	41.25
	wk 4	2	42.27	0.12728	0.09	41.12644	43.41356	42.18	42.36
	Total	8	41.23875	0.68987	0.24	40.662	41.8155	40.47	42.36

I (2)

ANOVA for chemical analysis conducted weekly on Wagashie sample PPSM

		Sum of Squares	df	Mean Square	F	Sig.
Moisture	Between Groups	3.271137	3	1.090379	71.32488	0.000628
	Within Groups	0.06115	4	0.015288		
	Total	3.332287	7			
Crude Protein	Between Groups	1.6295	3	0.543167	14.81027	0.012432
	Within Groups	0.1467	4	0.036675		
	Total	1.7762	7			
Fat	Between Groups	2.933537	3	0.977846	9.828831	0.025663
	Within Groups	0.39795	4	0.099487		
	Total	3.331487	7			

I (3) LSD of data gathered on chemical analysis conducted weekly on Wagashie sample PPSM

(Multiple Comparisons)

Dependent Variable	(I) Wagashie(PPSM	(J) Wagashie(PPSM	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Moisture	wk 0	wk1	1.15000*	0.12364	0.001	0.8067	1.4933
		wk2	1.78000*	0.12364	0	1.4367	2.1233
		wk 4	.88500*	0.12364	0.002	0.5417	1.2283
	wk1	wk 0	-1.15000*	0.12364	0.001	-1.4933	-0.8067
		wk2	.63000*	0.12364	0.007	0.2867	0.9733
		wk 4	-0.265	0.12364	0.099	-0.6083	0.0783
	wk2	wk 0	-1.78000*	0.12364	0	-2.1233	-1.4367
		wk1	-.63000*	0.12364	0.007	-0.9733	-0.2867
		wk 4	-.89500*	0.12364	0.002	-1.2383	-0.5517
	wk 4	wk 0	-.88500*	0.12364	0.002	-1.2283	-0.5417
		wk1	0.265	0.12364	0.099	-0.0783	0.6083
		wk2	.89500*	0.12364	0.002	0.5517	1.2383
Crude Protein	wk 0	wk1	-0.405	0.19151	0.102	-0.9367	0.1267
		wk2	-1.21000*	0.19151	0.003	-1.7417	-0.6783
		wk 4	-0.265	0.19151	0.239	-0.7967	0.2667
	wk1	wk 0	0.405	0.19151	0.102	-0.1267	0.9367
		wk2	-.80500*	0.19151	0.014	-1.3367	-0.2733
		wk 4	0.14	0.19151	0.505	-0.3917	0.6717
	wk2	wk 0	1.21000*	0.19151	0.003	0.6783	1.7417
		wk1	.80500*	0.19151	0.014	0.2733	1.3367
		wk 4	.94500*	0.19151	0.008	0.4133	1.4767
	wk 4	wk 0	0.265	0.19151	0.239	-0.2667	0.7967
		wk1	-0.14	0.19151	0.505	-0.6717	0.3917
		wk2	-.94500*	0.19151	0.008	-1.4767	-0.4133

Continuation of I (3)

Fat	wk 0	wk1	0.28	0.31542	0.425	-0.5957	1.1557
		wk2	0.02	0.31542	0.952	-0.8557	0.8957
		wk 4	-1.27500*	0.31542	0.016	-2.1507	-0.3993
	wk1	wk 0	-0.28	0.31542	0.425	-1.1557	0.5957
		wk2	-0.26	0.31542	0.456	-1.1357	0.6157
		wk 4	-1.55500*	0.31542	0.008	-2.4307	-0.6793
	wk2	wk 0	-0.02	0.31542	0.952	-0.8957	0.8557
		wk1	0.26	0.31542	0.456	-0.6157	1.1357
		wk 4	-1.29500*	0.31542	0.015	-2.1707	-0.4193
	wk 4	wk 0	1.27500*	0.31542	0.016	0.3993	2.1507
		wk1	1.55500*	0.31542	0.008	0.6793	2.4307
		wk2	1.29500*	0.31542	0.015	0.4193	2.1707

*. The mean difference is significant at the 0.05 level.

J (1) Statistical description of the data gathered on chemical analysis conducted weekly on Wagashie sample PFFM

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Min	Max
						Lower Bound	Upper Bound		
Moisture	wk 0	2	48.46	0.014142	0.01	48.33294	48.58706	48.45	48.47
	wk1	2	45.76	0.127279	0.09	44.61644	46.90356	45.67	45.85
	wk2	2	45.47	0.127279	0.09	44.32644	46.61356	45.38	45.56
	wk 4	2	44.9	0	0	44.9	44.9	44.9	44.9
	Total	8	46.1475	1.466714	0.518562	44.9213	47.3737	44.9	48.47
Crude Protein	wk 0	2	19.79	0.268701	0.19	17.37582	22.20418	19.6	19.98
	wk1	2	20.51	0.014142	0.01	20.38294	20.63706	20.5	20.52
	wk2	2	20.075	0.26163	0.185	17.72435	22.42565	19.89	20.26
	wk 4	2	20.155	0.247487	0.175	17.93141	22.37859	19.98	20.33
	Total	8	20.1325	0.322789	0.114123	19.86264	20.40236	19.6	20.52
Fat	wk 0	2	43.47	0.141421	0.1	42.19938	44.74062	43.37	43.57
	wk1	2	41.065	0.06364	0.045	40.49322	41.63678	41.02	41.11
	wk2	2	42.94	0.183848	0.13	41.28819	44.59181	42.81	43.07
	wk 4	2	42.51	0.183848	0.13	40.85819	44.16181	42.38	42.64
	Total	8	42.49625	0.96208	0.340147	41.69193	43.30057	41.02	43.57

J (2)

ANOVA for chemical analysis conducted weekly on Wagashie sample PFFM						
		Sum of Squares	df	Mean Square	F	Sig.
Moisture	Between Groups	15.02615	3	5.008717	614.5665	8.78E-06
	Within Groups	0.0326	4	0.00815		
	Total	15.05875	7			
Crude Protein	Between Groups	0.52725	3	0.17575	3.478476	0.129888
	Within Groups	0.2021	4	0.050525		
	Total	0.72935	7			
Fat	Between Groups	6.387538	3	2.129179	92.92653	0.000373
	Within Groups	0.09165	4	0.022912		
	Total	6.479188	7			

J (3) LSD on data gathered on chemical analysis conducted weekly on Wagashie sample PFFM

(Multiple Comparisons)

Dependent Variable	(I) Wagashie(PFFM	(J) Wagashie(PFFM	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Moisture	wk 0	wk1	2.70000*	0.09028	0	2.4493	2.9507
		wk2	2.99000*	0.09028	0	2.7393	3.2407
		wk 4	3.56000*	0.09028	0	3.3093	3.8107
	wk1	wk 0	-2.70000*	0.09028	0	-2.9507	-2.4493
		wk2	.29000*	0.09028	0.033	0.0393	0.5407
		wk 4	.86000*	0.09028	0.001	0.6093	1.1107
	wk2	wk 0	-2.99000*	0.09028	0	-3.2407	-2.7393
		wk1	-.29000*	0.09028	0.033	-0.5407	-0.0393
		wk 4	.57000*	0.09028	0.003	0.3193	0.8207
	wk 4	wk 0	-3.56000*	0.09028	0	-3.8107	-3.3093
		wk1	-.86000*	0.09028	0.001	-1.1107	-0.6093
		wk2	-.57000*	0.09028	0.003	-0.8207	-0.3193
Crude Protein	wk 0	wk1	-.72000*	0.22478	0.033	-1.3441	-0.0959
		wk2	-0.285	0.22478	0.274	-0.9091	0.3391
		wk 4	-0.365	0.22478	0.18	-0.9891	0.2591
	wk1	wk 0	.72000*	0.22478	0.033	0.0959	1.3441
		wk2	0.435	0.22478	0.125	-0.1891	1.0591
		wk 4	0.355	0.22478	0.189	-0.2691	0.9791
	wk2	wk 0	0.285	0.22478	0.274	-0.3391	0.9091
		wk1	-0.435	0.22478	0.125	-1.0591	0.1891
		wk 4	-0.08	0.22478	0.74	-0.7041	0.5441
	wk 4	wk 0	0.365	0.22478	0.18	-0.2591	0.9891
		wk1	-0.355	0.22478	0.189	-0.9791	0.2691
		wk2	0.08	0.22478	0.74	-0.5441	0.7041

Continuation of J (3)

Fat	wk 0	wk1	2.40500*	0.15137	0	1.9847	2.8253
		wk2	.53000*	0.15137	0.025	0.1097	0.9503
		wk 4	.96000*	0.15137	0.003	0.5397	1.3803
	wk1	wk 0	-2.40500*	0.15137	0	-2.8253	-1.9847
		wk2	-1.87500*	0.15137	0	-2.2953	-1.4547
		wk 4	-1.44500*	0.15137	0.001	-1.8653	-1.0247
	wk2	wk 0	-.53000*	0.15137	0.025	-0.9503	-0.1097
		wk1	1.87500*	0.15137	0	1.4547	2.2953
		wk 4	.43000*	0.15137	0.047	0.0097	0.8503
	wk 4	wk 0	-.96000*	0.15137	0.003	-1.3803	-0.5397
		wk1	1.44500*	0.15137	0.001	1.0247	1.8653
		wk2	-.43000*	0.15137	0.047	-0.8503	-0.0097

*. The mean difference is significant at the 0.05 level.

K (1) Statistical description of the data gathered on chemical analysis conducted weekly on Wagashie sample D

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Min	Max
						Lower Bound	Upper Bound		
Moisture	wk 0	2	63.8	0.042426	0.03	63.41881	64.18119	63.77	63.83
	wk1	2	51.855	0.091924	0.065	51.0291	52.6809	51.79	51.92
	wk2	2	47.415	0.049497	0.035	46.97028	47.85972	47.38	47.45
	wk 4	2	50.46	0.098995	0.07	49.57057	51.34943	50.39	50.53
	Total	8	53.3825	6.655199	2.352968	47.81861	58.94639	47.38	63.83
Crude Protein	wk 0	2	16.935	0.13435	0.095	15.72791	18.14209	16.84	17.03
	wk1	2	20.62	0.113137	0.08	19.6035	21.6365	20.54	20.7
	wk2	2	21.185	0.26163	0.185	18.83435	23.53565	21	21.37
	wk 4	2	20.27	0.410122	0.29	16.5852	23.9548	19.98	20.56
	Total	8	19.7525	1.784415	0.630886	18.26069	21.24431	16.84	21.37
Fat	wk 0	2	31.41	0.282843	0.2	28.86876	33.95124	31.21	31.61
	wk1	2	32.315	0.021213	0.015	32.12441	32.50559	32.3	32.33
	wk2	2	36.32	0.296985	0.21	33.6517	38.9883	36.11	36.53
	wk 4	2	36.63	0.367696	0.26	33.32639	39.93361	36.37	36.89
	Total	8	34.16875	2.500551	0.884078	32.07824	36.25926	31.21	36.89

K (2)

ANOVA for the data on chemical analysis conducted weekly on Wagashie sample D

		Sum of Squares	df	Mean Square	F	Sig.
Moisture	Between Groups	310.0193	3	103.3398	18371.51	9.87E-09
	Within Groups	0.0225	4	0.005625		
	Total	310.0418	7			
Crude Protein	Between Groups	22.02145	3	7.340483	109.7642	0.000269
	Within Groups	0.2675	4	0.066875		
	Total	22.28895	7			
Fat	Between Groups	43.46544	3	14.48848	190.732	9.02E-05
	Within Groups	0.30385	4	0.075963		
	Total	43.76929	7			

K (3) LSD for the data gathered on chemical analysis conducted weekly on Wagashie sample D

(Multiple Comparisons)

Dependent Variable	(I) Wagashie(D)	(J) Wagashie(D)	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Moisture	wk 0	wk1	11.94500*	0.075	0	11.7368	12.1532
		wk2	16.38500*	0.075	0	16.1768	16.5932
		wk 4	13.34000*	0.075	0	13.1318	13.5482
	wk1	wk 0	-11.94500*	0.075	0	-12.1532	-11.7368
		wk2	4.44000*	0.075	0	4.2318	4.6482
		wk 4	1.39500*	0.075	0	1.1868	1.6032
	wk2	wk 0	-16.38500*	0.075	0	-16.5932	-16.1768
		wk1	-4.44000*	0.075	0	-4.6482	-4.2318
		wk 4	-3.04500*	0.075	0	-3.2532	-2.8368
	wk 4	wk 0	-13.34000*	0.075	0	-13.5482	-13.1318
		wk1	-1.39500*	0.075	0	-1.6032	-1.1868
		wk2	3.04500*	0.075	0	2.8368	3.2532
Crude Protein	wk 0	wk1	-3.68500*	0.2586	0	-4.403	-2.967
		wk2	-4.25000*	0.2586	0	-4.968	-3.532
		wk 4	-3.33500*	0.2586	0	-4.053	-2.617
	wk1	wk 0	3.68500*	0.2586	0	2.967	4.403
		wk2	-0.565	0.2586	0.094	-1.283	0.153
		wk 4	0.35	0.2586	0.247	-0.368	1.068
	wk2	wk 0	4.25000*	0.2586	0	3.532	4.968
		wk1	0.565	0.2586	0.094	-0.153	1.283
		wk 4	.91500*	0.2586	0.024	0.197	1.633
	wk 4	wk 0	3.33500*	0.2586	0	2.617	4.053
		wk1	-0.35	0.2586	0.247	-1.068	0.368
		wk2	-.91500*	0.2586	0.024	-1.633	-0.197

Continuation of K(3)

Fat	wk 0	wk1	-.90500*	0.27561	0.03	-1.6702	-0.1398
		wk2	-4.91000*	0.27561	0	-5.6752	-4.1448
		wk 4	-5.22000*	0.27561	0	-5.9852	-4.4548
	wk1	wk 0	.90500*	0.27561	0.03	0.1398	1.6702
		wk2	-4.00500*	0.27561	0	-4.7702	-3.2398
		wk 4	-4.31500*	0.27561	0	-5.0802	-3.5498
	wk2	wk 0	4.91000*	0.27561	0	4.1448	5.6752
		wk1	4.00500*	0.27561	0	3.2398	4.7702
		wk 4	-0.31	0.27561	0.324	-1.0752	0.4552
	wk 4	wk 0	5.22000*	0.27561	0	4.4548	5.9852
		wk1	4.31500*	0.27561	0	3.5498	5.0802
		wk2	0.31	0.27561	0.324	-0.4552	1.0752

*. The mean difference is significant at the 0.05 level.

L (1). DESCRIPTIVE SENSORY EVALUATION DATA FOR THE ALL THE FRIED WAGASHIE SAMPLES IN THEIR FRESH FORMS (ZERO WEEKS OLD)

Panelist	Attribute- Golden brown											
	535	**/272**	**/222**	**302**	**/957**	**/666**	**822**	**/179**	**/333**	**612**	**/467**	**/888**
1	2.8	1.6	2.4	1.8	4.3	4	1.7	3	2.3	2.6	2.9	2.3
2	1.4	4.7	2.9	0.3	1.6	2	2.2	2.5	4.7	3.5	4.5	3.1
3	3	2.3	3.1	1.9	2.2	1	1.5	1.9	2.9	4.5	2.8	4.4
4	1.9	0.5	1	0.9	0.1	1	0.6	3.5	2.5	0.4	0.5	1.8
5	2.3	1.5	2.7	4.6	4.9	4	0.7	0.3	1.4	5.3	5.1	4.7
6	0.4	0.8	1.8	2.7	2.2	3	3.4	1.1	2.9	4.3	1.1	3.2
7	2.5	1.3	3.2	3.1	3.9	4	1.7	3.1	2.6	2.8	0.7	0.4
8	4.1	4.3	5.3	1.4	0.9	2	0.2	3	3.6	1.2	0.5	0.9
9	1.6	2.7	2.3	2.7	1.9	1	1.2	0.6	1.8	1.1	2	2.6
10	4.7	2.9	4	0.5	0.9	2	2.6	1.1	2.3	2	1.5	3.6

Continuation of L(1)

Panelist	Attribute-Rough											
	535	**/272**	**/222**	**302**	**/957**	**/666**	**822**	**/179**	**/333**	**612**	**/467**	**/888**
1	3.1	0.9	1.3	4.6	4	4	4.5	4.3	2.9	6.6	7.1	8
2	3.8	4.1	4.3	5.7	5.3	5	3.9	5.1	2.8	7.6	8.1	6.6
3	3	3.7	3.5	4.6	5.2	4	4.1	3.7	3.5	8.5	6.9	7.1
4	1.7	1.2	2	4.8	5.8	6	2.9	2.6	1.7	6.2	6.6	5.8
5	1.5	2.7	2.1	7.2	9.8	7	0.6	0.9	2.1	8.5	9.1	8.9
6	1.2	2.4	0.6	6.6	8.1	9	1.4	1.7	2.4	6.4	5.6	5.9
7	3.8	2.4	3	5.2	4.5	5	1	1	1.3	7.2	6.1	6.4
8	2.4	2.7	1.8	8.1	7.9	8	2.6	0.4	0.3	7.7	7.9	7
9	0.7	1.2	1.6	5.3	6.1	6	4.5	4.1	4.8	5.3	5.8	7.3
10	0.9	2.6	1.2	4.2	7.5	6	3.7	1.6	2.2	7.3	6.1	5.2

Panelist	Attribute-Compact											
	535	**/272**	**/222**	**302**	**/957**	**/666**	**822**	**/179**	**/333**	**612**	**/467**	**/888**
1	8.9	8.1	8.3	4.6	4.3	5	9.4	7.2	8.5	1.2	0.5	0.7
2	8.1	8.1	7.5	2.5	1.5	3	6.5	6.7	6.1	1.4	1.7	1.9
3	6.9	7.2	6.4	3.4	2	4	5.3	5.8	6.1	2.7	2.6	1.1
4	8.6	9.3	9.7	2.7	3.1	3	4.2	5.7	6.3	0.9	1.3	1.8
5	10	9.2	9	5.2	4.9	6	7.8	7.1	7.3	1.2	1.8	1.4
6	6.7	7.3	6.9	2.9	3.7	4	6.6	6.1	5.8	2.3	2.7	1.9
7	10	10	9.8	6.1	5.8	5	8.2	6.9	7.5	3.5	2.3	2.2
8	8	7.8	8.2	2.4	2.1	2	4.8	4.6	6.2	0.7	1.1	2.1
9	9.6	9.1	8.9	0.6	1.1	1	5.1	6.8	7.1	3.3	3.1	3.4
10	7.5	5.8	6.1	1.5	1.7	1	6.3	7.5	8.1	3.2	1.9	3.6

Panelist	Attribute-Soft											
	535	**/272**	**/222**	**302**	**/957**	**/666**	**822**	**/179**	**/333**	**612**	**/467**	**/888**
1	1.4	4.1	3.7	3.6	3.7	3	6.6	7.6	7.1	1.5	3	2.8
2	5.2	4.9	4.5	2.3	3.5	2	7.3	7.1	7.8	2	1.2	1.8
3	3.4	4.5	3	3.7	2.3	2	5.4	4.9	5.5	3	0.8	1.3
4	2.4	3.8	2.1	2.7	2.6	3	4.7	4.9	4.4	0.2	0.9	0.7
5	1.7	2.7	2.3	2.4	2	2	5	5.3	6.1	1.2	0.9	1.1
6	4.8	4.2	4.5	3.3	3.5	4	8.7	8.1	7.5	3.1	2.9	3
7	5	4.8	3.9	0.8	0.5	1	4.2	4.9	5.8	5.2	4.4	4.1
8	6.1	6	6.5	0.2	0.4	1	9.7	9.1	9	2.1	3.6	2.4
9	5.3	5	4.7	1.6	1.3	2	5	6.2	6.4	3	2.6	1.1
10	4.9	6.2	5.3	2.4	2	2	5.4	7.7	5.9	1.9	2.5	4.3

Continuation of L(1)

Panelist	Attribute-Soggy											
	535	**/272**	**/222**	**302**	**/957**	**/666**	**822**	**/179**	**/333**	**612**	**/467**	**/888**
1	2.5	3	2.3	3.5	3.1	4	1.1	4.1	1.8	3.8	5.7	2.9
2	1.8	0.9	1.4	5	4.3	5	0.2	0.5	0.8	5.4	3.5	6
3	3.9	3.6	4.1	3.7	4	3	1.6	2.1	4.1	5.3	3.7	4.7
4	1.7	2.3	2.8	2.9	2.4	3	3.2	0.2	1.5	5.5	6.3	4.9
5	1.8	0.4	1	2.6	5.1	4	3.1	2	2.6	7.8	6.7	7.1
6	1.4	0.9	0.8	1	1.6	1	3.4	3.5	3	5.3	3.4	6.1
7	1.2	1.9	2.5	2.9	1.8	2	2.2	1.6	1.3	4.1	5.8	6.5
8	1.7	3.4	2.5	1.2	2.5	3	0.7	0.9	1.7	2	3.5	4
9	1.9	0.9	1.1	4.7	5.4	2	4.9	2	2.5	2.6	4.9	3.9
10	0.5	2.8	1.8	5.2	5	4	0.7	0.9	1.3	5	4.8	5.3

Panelist	Attribute-Chewable											
	535	**/272**	**/222**	**302**	**/957**	**/666**	**822**	**/179**	**/333**	**612**	**/467**	**/888**
1	1.7	1.9	2.4	2.1	1.4	2	5.9	5.6	4.6	1.3	0.9	1.1
2	3.8	4	3.3	2.8	2	1	4.3	5.1	5	1.1	2.3	1.5
3	4	2.7	1.9	3	4	3	3.5	4	2.1	2.8	3.2	2.5
4	4.2	5	4.5	4.1	4.2	5	5.3	6.4	3.6	0.8	0.2	0.6
5	4.5	5.2	4.8	2.1	2.3	4	5.1	5.5	6.4	2.9	0.9	2
6	3.9	2.4	3.3	2.6	1.4	4	1.5	2	1.7	2.8	2.6	3.3
7	5	4.3	4.6	2.8	4.1	3	5.2	4.2	3.7	4.1	1.9	3.2
8	0.5	1.5	0.1	0.4	0.3	0	2.2	3.8	1.7	4.6	2.9	4.1
9	1.9	1.3	1.4	0.6	1.1	2	0.9	1.4	2.1	2.7	3.1	3.4
10	3.5	4	4.1	3.9	4.5	3	3.4	1.6	2.4	3.1	4.5	3

Panelist	Attribute-Friable											
	535	**/272**	**/222**	**302**	**/957**	**/666**	**822**	**/179**	**/333**	**612**	**/467**	**/888**
1	5.7	4.5	4	4.5	3.9	6	3	3.1	4.9	7.6	5.9	7.2
2	2.4	3.2	2.8	2.7	4.2	3	2.2	1.7	4.3	6.1	6.8	6.5
3	3.3	3.6	2.2	3.7	3.7	5	2.6	1.5	3.8	5	4.9	5.7
4	6.2	6.6	5.4	8.2	7.5	10	2.5	2.5	2.1	6.3	9.2	9.8
5	3.2	4.3	2.7	7.3	6.3	7	1.8	1.2	2.7	8.5	6.9	7.8
6	1.9	1.6	2.1	7.1	8.3	8	1	1.4	1.6	9.1	9.4	8.7
7	5.3	5.1	4.9	5.4	5.9	7	2.7	4.1	3	4.3	6.4	6.8
8	3.5	3.1	4.3	6	7.4	6	2	2.3	1.8	3.6	6.4	7.2
9	5.1	4.3	4.8	4.8	4.9	5	3.8	3.1	4.1	5.3	4.4	6.8
10	5.1	2.6	4.3	6.9	7.5	8	2	3.3	4.2	7.7	9.3	8.9

Continuation of L(1)

Panelist	Attribute- Typical of Wagashie											
	535	**/272**	**/222**	**302**	**/957**	**/666**	**822**	**/179**	**/333**	**612**	**/467**	**/888**
1	9.3	8.9	9	2.2	0.7	2	9.8	8.1	8.5	0	0.1	0.1
2	8	6.8	6.4	1.3	1.4	2	9.9	9.7	10	1	0.6	0.4
3	5	6.6	4.9	4.3	3	4	7.1	4.2	6.3	1.3	1	1.9
4	8.9	10	9.5	1.9	2.5	2	8.2	9.9	7.7	1.3	0.8	1.6
5	7.3	8.4	8.1	3.3	3.7	3	8.9	9	8.2	0.5	1.1	1.8
6	3.9	5.1	4.8	3.6	1.4	5	6.1	3.1	5.4	1	2.4	1.2
7	6.3	7.8	5.5	3.6	4.7	4	7.9	6.4	4.3	0.6	1.7	1.1
8	4.9	6.9	7	1.6	1.8	2	6.7	8.8	7	1.5	4.6	3.1
9	8.4	7.6	9.1	1	1.3	4	4.9	6.4	5.9	0.4	1.9	0.6
10	8.1	7.3	6.2	2.7	1.9	3	8	5.1	7.2	2.4	0.8	1.8

Panelist	Attribute- Flat											
	535	**/272**	**/222**	**302**	**/957**	**/666**	**822**	**/179**	**/333**	**612**	**/467**	**/888**
1	5.2	4.8	6	2.8	1.7	1	5.1	3.8	4.8	0.9	1.2	1
2	3.9	3.4	4.2	2.1	1.3	4	5.9	5.5	6.3	1.5	0.4	2.1
3	6.5	5.8	5.6	5	3.8	3	7.1	6	4.9	1.7	1.2	1.6
4	7.3	5.8	3.6	1.3	2.9	2	4.5	6.2	5	2.1	4.5	1.8
5	2.9	3.1	2.7	1.8	2.3	3	4.8	3.7	2.9	1.3	0.6	1
6	4.8	3.2	5.1	1.4	1.1	2	4.3	3	3.8	0.8	2.2	1.3
7	4	4.6	3.9	4.8	0.9	1	7	6.1	5.7	4.4	3.2	1.8
8	2.5	1.9	1.7	1.2	0.3	2	2.2	1.6	2.5	1.6	2.3	3.7
9	6.1	4.8	6.7	5.1	4.7	3	4.8	2.9	4	4.8	1.1	2.2
10	1.5	2.4	3.4	1.5	1.3	2	1.3	3.6	3	0.9	1.5	1.3

L (2). DESCRIPTIVE SENSORY EVALUATION DATA FOR THE ALL THE FRIED WAGASHIE SAMPLES IN THEIR STORED FORMS (FOUR WEEKS OLD)

Panelist	Attribute- Golden brown											
	535	**/272**	**/222**	**302**	**/957**	**/666**	**822**	**/179**	**/333**	**612**	**/467**	**/888**
1	4.8	3.1	2.1	3.3	5.2	3.1	3	9.3	3.4	2.1	1.1	2
2	2.3	2.2	1.6	2.3	2.4	3.9	4.2	4.4	3.6	0.6	0.4	2.1
3	4.5	2.9	3.2	2.6	3	2	2.4	3.1	2.3	1.6	3.3	1.1
4	0.4	0.9	1.6	0.2	3.6	0.9	0.2	1.1	2.1	2.7	4.1	3.5
5	2	0.7	2.5	3.9	2.9	2.5	2.9	1.8	2.4	0.4	0.8	0.2
6	1.2	1.3	2.9	1.3	1.3	1.1	1.4	3.7	1	2.5	2.3	1.3
7	4.3	4.6	4	3.5	2.8	1.9	1.1	2.3	2.1	3.3	3.8	2.4
8	0.3	0.4	2.4	0.7	2.4	3.7	1.3	2	5.3	3.2	0.4	2.5
9	1.6	1.3	1.8	1.5	1.2	1	4.6	4.1	4.3	4.3	1.4	1.1
10	1.2	2.1	2.7	1.3	3.1	2.5	2.1	2.6	3.9	3.8	3.9	2.8

Panelist	Attribute- Rough											
	535	**/272**	**/222**	**302**	**/957**	**/666**	**822**	**/179**	**/333**	**612**	**/467**	**/888**
1	4.3	4.4	3.1	6	5.3	6.1	4.3	4	3.2	7	5.8	7.8
2	2.7	3.7	2.2	6.2	6.3	5.8	4.1	2.8	1.9	8.4	8.1	8.6
3	1.7	1.5	1.9	6.7	5	5.5	4.9	3.5	3.7	6.7	5.2	7.3
4	0.2	0.7	0.4	8.9	7.1	7.4	0.7	0.9	0.3	7.9	8.1	7.4
5	1.9	2.3	2.5	9.2	8	5.8	0.7	1.3	1.8	5.8	6	6.2
6	2.2	2	2.8	7.9	7.3	6	2.7	2.9	2.5	6.6	6.7	6.4
7	3	1.7	1.9	4.8	5	5.2	3.6	2.9	3.3	4.6	5.9	5.1
8	0.4	1.4	1.1	4.8	5.3	4.9	2	2.6	3.1	8.7	8.3	8.5
9	3.2	2.8	2.1	4.7	4.9	5.6	4.1	3.7	4	7.3	8.1	7.9
10	3.4	2.6	1.8	7	6.7	7.2	2.6	3.2	3.9	5.5	5.4	6.7

Panelist	Attribute- Compact											
	535	**/272**	**/222**	**302**	**/957**	**/666**	**822**	**/179**	**/333**	**612**	**/467**	**/888**
1	8.4	8.1	8.3	1.6	0.6	0.9	5.8	7.3	6.8	4.1	3.8	3.4
2	6.3	6.9	7.3	2.5	1.9	3.1	6.4	5.7	6.2	2.1	1.9	3.5
3	9.2	9	8.8	2.8	3.4	3.3	8.4	8	8.1	2.7	3.8	2.1
4	6.5	7.1	5.9	1.3	1.3	2.1	6.7	7.3	8.2	1.4	2.9	3.2
5	6.3	6.5	6.1	1	1.3	1.9	5.6	5.1	4.9	0.4	0.8	1.5
6	7.3	7.1	7.5	2.5	2.9	3.1	7.4	6.6	8.2	1.3	1.4	2.1
7	5.8	4.3	5.6	2.1	2.7	2.4	5.4	6.3	7.3	1.1	1.7	1.5
8	5.3	6.3	5.7	3	3.7	3.6	7.3	5.4	7.1	0.8	0.1	0.2
9	7	6.5	7.3	4.6	4.1	5.2	6.3	6.7	5.8	0.3	0.6	1.2
10	8.1	8.3	7.8	4.8	1.4	1.9	5.7	5.9	5.6	2.8	2	3.1

Continuation of L(2)

Panelist	Attribute-Soft											
	535	**/272**	**/222**	**302**	**/957**	**/666**	**822**	**/179**	**/333**	**612**	**/467**	**/888**
1	3.9	4.3	2.9	0.4	0.6	1	6.2	5.2	4.8	1.1	5.1	1.8
2	1.9	2.6	2.1	3	3.2	2.9	5.2	3.7	4.2	2.3	3.9	1.5
3	4.6	4.7	4.2	2.1	1	1.8	4.8	5.5	5.9	3	3.9	2.6
4	5	5.1	3.6	3.4	2.6	3	6.8	6.4	7.2	2.1	4.3	2.5
5	1.3	0.8	1.5	1.5	1.9	2.2	3.9	6.9	4.5	0.8	0.8	0.5
6	2	2	2.7	1.9	0.8	1.3	5.7	2.8	4.7	1.3	1.6	2.1
7	4	4.1	3.5	2.6	3.4	1.4	5.4	5.3	6	2.2	2.4	3.2
8	1.6	2	2.3	0.3	1.4	2.1	5.9	6.1	6.4	2.1	0.4	1.3
9	3.5	4	4.3	0.7	0.9	1.3	7.9	8.8	7.1	0.6	0.4	0.9
10	5	5.4	4.8	1	1.4	2	5.6	5.8	5	1.1	0.5	1.5

Panelist	Attribute-Soggy											
	535	**/272**	**/222**	**302**	**/957**	**/666**	**822**	**/179**	**/333**	**612**	**/467**	**/888**
1	1.3	4.7	2.9	1	3.5	2.9	1.7	2.1	1.3	5.5	6.1	5
2	2.5	3.2	2.8	5.1	5.6	4.4	0.9	1.1	0.6	4.5	5.3	4.7
3	2.7	2.5	1.9	3.7	2.9	3.4	2.3	1.9	1.2	2.8	3.2	2.4
4	1.6	2.2	3	4.2	4.7	4.1	2.7	2	2.3	2	2.3	1.9
5	3.6	4.6	3.9	6.2	5.7	6	0.9	0.9	0.4	6.4	6.1	5.8
6	3.2	3.1	3.5	3.8	2.3	4.1	1.1	2.1	1.4	3.5	3.5	4.5
7	1.8	2.1	1.3	5.4	5.8	4.3	2.9	3.4	2.5	5.4	6	6.4
8	0.4	0.8	1.1	3.1	2.2	2.7	0.4	0.5	1.6	7.3	6.1	7
9	1.6	2.4	1.3	4.6	2.4	4	2.7	1.7	2.1	5.3	5	2.7
10	0.9	0.7	1.2	3.9	3.6	4.3	0.5	0.5	1.3	0.8	1.1	1.2

Panelist	Attribute-Chewable											
	535	**/272**	**/222**	**302**	**/957**	**/666**	**822**	**/179**	**/333**	**612**	**/467**	**/888**
1	5.4	5	4.3	4.8	5.4	3.9	5.7	4.9	3.6	5.2	5.8	4.3
2	3.7	2.8	3.1	3.4	3.7	4.1	4.3	2.5	4.1	3.6	3.5	2.7
3	3.5	4.6	4	4.4	4.7	4.5	4.1	3.8	5.1	2.9	3.9	1.4
4	3.5	2.8	2.3	4.7	8	5.1	2.7	1.6	3.3	2.9	3.3	1.7
5	1.3	0.7	1.1	1.4	1.4	2.3	0.9	2.8	1	1	0.9	1.1
6	1.2	1.6	2.2	2.7	2	2.1	1.8	2.3	2.5	1.3	1.8	1
7	5.2	5.6	4.2	5.3	6.4	5.1	4.3	3.6	3.1	2.2	2.3	2.1
8	0.4	1.7	2.1	0.4	0.3	1.5	2.1	0.4	1.8	1.8	1.1	0.9
9	1.9	1.3	1.4	4.7	5.3	4.2	2.2	3.2	2.6	3	2.2	2.4
10	4.7	5.7	4	4.4	2.5	3.4	6.8	5.2	5	3.5	2.8	3.9

Continuation of L (2)

Panelist	Attribute- Friable											
	535	**/272**	**/222**	**302**	**/957**	**/666**	**822**	**/179**	**/333**	**612**	**/467**	**/888**
1	1.4	1.1	2.8	5.5	3.8	2.5	0.9	3.9	1.9	7	5.6	7
2	2.7	3.4	4.1	5	3.6	2.9	2.7	2.6	1.8	3.1	4.4	6.4
3	4.8	4	3.9	4.6	4.9	4	3.2	4.5	3	4.1	5.2	5.8
4	3.4	2.6	4.1	4.8	6.6	5.7	2.2	4.3	2.1	7.7	8.8	6.1
5	1.8	2.5	3.2	4.9	6	6.1	1	0.9	1.5	5.3	8.4	8
6	2.8	2.2	1.9	6.5	7	7.3	1.4	1.3	1.8	7.1	7.7	8.1
7	1.8	2.1	3.6	4.5	4.2	3.1	1.1	1.4	2.6	3.1	3.7	4.5
8	0.8	1.3	0.9	3.1	2.8	2.3	1	2.1	3.8	5.6	1.1	4.8
9	5.1	4.2	4	5.2	5	5.4	1.7	3.6	3	6.6	6.8	3.7
10	2.9	1.1	3.8	4.2	5	3.8	2.6	2.1	2.9	5.6	4.4	4.8

Panelist	Attribute- Typical of Wagashie											
	535	**/272**	**/222**	**302**	**/957**	**/666**	**822**	**/179**	**/333**	**612**	**/467**	**/888**
1	6.7	7.4	7.8	4.8	4.5	5.7	5	8	6.1	2.1	0.6	1.9
2	6.1	6.3	6.8	6.3	5.1	3.7	2.6	4.7	7.2	2.2	3.3	3.7
3	8.9	7.2	9	4	4.9	4.1	5.6	4.7	5.9	2.2	4.2	1
4	10	10	6.9	2.3	2.9	2.5	9.8	7.6	8	1.8	2.7	2.9
5	5.8	5.6	6.1	1.8	2.5	2.1	9.6	9.6	10	1.5	1.2	3.4
6	4.5	5.1	4.3	2.8	2.2	3.1	5.4	4.8	6.7	3.1	1.6	3.4
7	4.8	4.3	6.5	1.1	1.4	3	6.2	8.3	8.1	1.1	1.3	1.6
8	7.2	7	7.7	1	0.3	1.9	9.3	5.7	5.9	4.2	3.8	3.1
9	9.2	6.2	6.6	4.1	2.5	3	9.4	8.3	7.1	5.6	3.6	3.1
10	3.9	4	5.8	0.9	1.3	1.1	4.3	4.9	4.1	2.8	1.9	1.6

Panelist	Attribute- Flat											
	535	**/272**	**/222**	**302**	**/957**	**/666**	**822**	**/179**	**/333**	**612**	**/467**	**/888**
1	3	1.1	4.1	10	3.6	6.2	5	10	7.3	4	6.9	5.1
2	3.7	2	3	9.7	9.8	8.4	9.6	9.1	9	9.8	9.6	7.3
3	4.1	3.3	1.9	6.6	5.6	7.1	8.1	8.3	9.1	8.8	8.2	5.8
4	5	4.3	2.5	10	9.5	10	8.2	7.6	6.1	9.9	10	8.2
5	1.5	1.5	2.9	7.5	8	8.3	9.5	9.2	7.8	9.2	9.5	9
6	4.7	5.1	3.3	8.7	8.4	9.3	6.8	6.5	7.2	5.3	6.3	7.1
7	5.2	4.2	5	5.3	5.5	5.9	8.1	7.4	4.7	5.1	5.9	5.5
8	2	3.4	3.8	6.3	9.1	4.4	5.3	5.7	4.9	4.1	6	5.4
9	6.8	5	4.2	8.2	7.1	6.8	6.1	8.5	8.9	8.8	9	6.1
10	2.4	3.7	4.9	5.1	7.4	6.2	7.1	5.4	6.5	5.3	3.4	5

535, 272, 222: PFFM
302, 957, 666: UFFM

822,179, 333: PPSM
612, 467, 888: D

M (1). Data on Chemical analysis carried out weekly on the four Wagashie Samples

% MOISTURE					
REPLICATE	WEEK	PFFM	UFFM	PPSM	D
1	0	48.45	47.36	47.86	63.77
2	0	48.47	47.34	47.65	63.83
1	1	45.85	45.68	46.66	51.92
2	1	45.67	45.83	46.55	51.79
1	2	45.38	46.1	46.1	47.38
2	2	45.56	45.85	45.85	47.45
1	4	44.9	45.79	46.9	50.53
2	4	44.9	45.79	46.84	50.39

% CRUDE PROTEIN					
REPLICATE	WEEK	PFFM	UFFM	PPSM	D
1	0	19.6	20.82	20.79	17.03
2	0	19.98	20.44	20.46	16.84
1	1	20.5	22.04	21.12	20.54
2	1	20.52	22.03	20.94	20.7
1	2	19.89	21.65	21.76	21
2	2	20.26	21.63	21.91	21.37
1	4	19.98	21.19	21.07	20.56
2	4	20.33	21.2	20.71	19.98

% FAT					
REPLICATE	WEEK	PFFM	UFFM	PPSM	D
1	0	43.37	41.11	40.76	31.61
2	0	43.57	41.17	41.23	31.21
1	1	41.11	40.21	40.96	32.33
2	1	41.02	40.08	40.47	32.3
1	2	43.07	38.99	40.7	36.53
2	2	42.81	39.1	41.25	36.11
1	4	42.64	39.36	42.18	36.89
2	4	42.38	39.69	42.36	36.37

	pH			
WEEK	PFFM	UFFM	PPSM	D
0	6.49	6.67	6.53	5.25
1	5.98	6.19	6.21	5.69
2	5.37	5.82	5.33	5.2
4	5.4	5.65	5.72	5.15

(N) Results of pre-sensory evaluation for PFFM and D samples (four evaluations each for PFFM and D samples)

	Compact				Springy			
Panelist	Sensory Score (PFFM)	%Relative Error	Sensory Score (D)	% Relative Error	Sensory Score (PFFM)	% Relative Error	Sensory Score (D)	% Relative Error
1*	8,9	14,91%	1	8,11%	5,4	5,68%	1,1	-13,04%
2	8,8	13,62%	0,6	-35,14%	7	36,99%	0,6	-52,57%
3*	8,3	7,17%	1,2	29,73%	6,3	23,29%	1,2	-5,14%
4	8,4	8,46%	1,2	29,73%	1,7	-66,73%	2,2	73,91%
5	9	16,20%	0,6	-35,14%	2,1	-58,90%	1,1	-13,04%
6*	9,1	17,50%	0,4	-56,76%	6	17,42%	2,2	73,91%
7*	5,3	-31,57%	0,2	-78,38%	3,1	-39,33%	1	-20,95%
8	5,6	-27,70%	0,3	-67,57%	4,4	-13,89%	3,2	152,96%
9*	7,8	0,71%	1,5	62,16%	4	-21,72%	1,1	-13,04%
10*	6,9	-10,91%	0,3	-67,57%	4,8	-6,07%	0,9	-28,85%
11	7,3	-5,75%	0,3	-67,57%	7,3	42,86%	0,9	-28,85%
12*	8,8	13,62%	1,2	29,73%	4,2	-17,81%	1,6	26,48%
13	5,7	-26,40%	2,9	213,51%	3,7	-27,59%	0,8	-36,76%
14	8,9	14,91%	1,5	62,16%	5,3	3,72%	2	58,10%
15*	7,6	-1,87%	1,1	18,92%	4,8	-6,07%	0,1	-92,09%
16*	9,3	20,08%	0,5	-45,95%	5,9	15,46%	0,5	-60,47%
17	8,4	8,46%	0,5	-45,95%	5,6	9,59%	0,6	-52,57%
18	7	-9,62%	1,3	40,54%	7,3	42,86%	2,1	66,01%
19	7,1	-8,33%	1,4	51,35%	8	56,56%	1,4	10,67%
20*	6,7	-13,49%	0,5	-45,95%	5,3	3,72%	0,7	-44,66%
MEAN	7,745		0,925		5,11		1,265	

Continuation of N

	Typical of Wagashie Aroma				Taste			
Panelist	Sensory Score (PFFM)	% Relative Error	Sensory Score (D)	% Relative Error	Sensory Score (PFFM)	% Relative Error	Sensory Score (D)	% Relative Error
1*	8,6	76,59%	0,8	-18,78%	3,8	21,02%	0,6	-58,62%
2	5,8	19,10%	1,6	62,44%	3,8	21,02%	2,5	72,41%
3*	6,6	35,52%	2,6	163,96%	3,9	24,20%	0,5	-65,52%
4	5,7	17,04%	0	-100,00%	5	59,24%	1,9	31,03%
5	5,8	19,10%	0,4	-59,39%	1,9	-39,49%	4	175,86%
6*	4,8	-1,44%	0,8	-18,78%	2,8	-10,83%	0,6	-58,62%
7*	3,6	-26,08%	1,6	62,44%	1,7	-45,86%	2,7	86,21%
8	4	-17,86%	0,3	-69,54%	1,8	-42,68%	0,2	-86,21%
9*	1,6	-67,15%	0,9	-8,63%	2,4	-23,57%	0,3	-79,31%
10*	3,5	-28,13%	1,9	92,89%	1,7	-45,86%	1	-31,03%
11	9	84,80%	0,2	-79,70%	4,3	36,94%	0,3	-79,31%
12*	5,1	4,72%	0	-100,00%	4	27,39%	6,1	320,69%
13	2	-58,93%	1,4	42,13%	4	27,39%	0,3	-79,31%
14	4,8	-1,44%	0	-100,00%	5,7	81,53%	1,3	-10,34%
15*	5,6	14,99%	1,2	21,83%	0,9	-71,34%	1,2	-17,24%
16*	6,9	41,68%	0,7	-28,93%	1,7	-45,86%	0,6	-58,62%
17	2,2	-54,83%	1	1,52%	3,3	5,10%	0,9	-37,93%
18	4,8	-1,44%	0,2	-79,70%	5	59,24%	0,3	-79,31%
19	3,3	-32,24%	1,7	72,59%	2,2	-29,94%	1,9	31,03%
20*	3,7	-24,02%	2,4	143,65%	2,9	-7,64%	1,8	24,14%
MEAN	4,87		0,985		3,14		1,45	

* Chosen panelists since their relative error was between - 50% and +50% in more than four evaluations

(O) Pearson Correlation analysis on data from Sensory Evaluation and Chemical Analysis

Sensory attributes	Golden brown	Rough	Soft	Compact	Soggy	Chewable	Friable	Typical of Wagashie	Flat	Moisture	Protein	Fat	FFA	pH
Golden brown	1													
Rough	0.14 *0.73*	1												
Soft	0.24 *0.56*	-0.9 *0.02*	1											
Compact	0.19 *0.66*	-0.99 *<.0001*	0.77 *0.02*	1										
Soggy	-0.21 *0.61*	0.95 *0.0004*	-0.83 *0.01*	-0.94 *0.001*	1									
Chewable	0.04 *0.92*	-0.53 *0.18*	0.54 *0.17*	0.48 *0.23*	-0.52 *0.19*	1								
Friable	0.19 *0.66*	0.90 *0.003*	-0.8 *0.02*	-0.84 *0.009*	0.9 *0.002*	-0.7 *0.05*	1							
Typical of Wagashie	0.14 *0.75*	-0.98 *<.0001*	0.85 *0.008*	0.97 *<.0001*	-0.95 *0.0002*	0.6 *0.11*	-0.93 *0.001*	1						
Flat	0.33 *0.42*	-0.02 *0.97*	0.11 *0.8*	-0.02 *0.96*	-0.13 *0.76*	0.51 *0.19*	-0.38 *0.35*	0.16 *0.71*	1					
Chemical parameters														
Moisture	0.15 *0.72*	0.53 *0.18*	-0.27 *0.52*	-0.48 *0.22*	0.64 *0.09*	-0.58 *0.14*	0.68 *0.06*	-0.57 *0.14*	-0.46 *0.25*	1				
Protein	-0.11 *0.80*	-0.32 *0.44*	0.24 *0.57*	0.27 *0.52*	-0.51 *0.20*	0.59 *0.12*	-0.57 *0.14*	0.41 *0.31*	0.62 *0.1*	-0.94 *0.0005*	1			
Fat	0.03 *0.94*	-0.78 *0.02*	0.5 *0.21*	0.78 *0.02*	-0.87 *0.005*	0.53 *0.18*	-0.77 *0.03*	0.79 *0.02*	0.22 *0.6*	-0.89 *0.003*	0.75 *0.03*	1		
FFA	0.24 *0.56*	0.35 *0.40*	-0.15 *0.72*	-0.41 *0.31*	0.28 *0.49*	0.1 *0.8*	-0.03 *0.94*	-0.23 *0.58*	0.83 *0.01*	-0.04 *0.92*	0.24 *0.56*	-0.28 *0.5*	1	
pH	-0.18 *0.68*	-0.4 *0.33*	0.43 *0.28*	0.45 *0.26*	-0.53 *0.18*	0.30 *0.47*	-0.23 *0.59*	0.4 *0.32*	-0.3 *0.48*	-0.37 *0.36*	0.35 *0.39*	0.59 *0.13*	-0.7 *0.06*	1

Figures in italics show probability levels. Probability level of interest is 0.05 and 0.01

P (1)

Plate 2: A picture of Sodom apple (*Calotropis procera*) plant

P (2)

Plate 3: Pictures of vacuum packaged Wagashie samples

P (3)

Plate 4: Vacuum packaged Wagashie samples prepared for storage in a climatic chamber