CONSUMPTION PATTERN AND EFFECT OF PROCESSING ON FATTY ACID PROFILE OF MILK FAT (*MANSHANU*) PRODUCED FROM MILK OF LOCAL COW BREEDS IN ZARIA

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SEPTEMBER, 2018

DECLARATION

I declare that the work in this dissertation entitled "**Consumption pattern and effect of processing on fatty acid profile of milk fat (*manshanu*) produced from milk of local cow breeds in Zaria"** has been carried out by me in the Department of Biochemistry. The information derived from the literature has been duly acknowledged in the text and a list of references provided. No part of this dissertation was previously presented for another degree or diploma at this or any other institution.

Abdullahi Suleiman

Student	Signature	Date

CERTIFICATION

This dissertation entitled "**CONSUMPTION PATTERN AND EFFECT OF PROCESSING ON FATTY ACID PROFILE OF MILK FAT (*MANSHANU*) PRODUCED FROM MILK OF LOCAL COW BREEDS IN ZARIA"** by Suleiman ABDULLAHI meets the regulations governing the award of the degree of Master of Science in Nutrition of the Ahmadu Bello University, and is approved for its contribution to knowledge and literary presentation.

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ABSTRACT

The consumption pattern and effect of processing on fatty acid profile of milk fat (*manshanu*) produced from milk of local cow breeds (Bunaji, Sokoto-Gudali) and Holstein-Friesian in Zaria raised under the same management system and the effect of onions used traditionally in frying milk fat for flavour enhancement and shelf life extension were investigated using standard methods. Cross sectional survey of 398 randomly selected households within Zaria LGA revealed that 87.7% of 349 households consumed milk fats, 35.5% consumed it at least once a week, and 15.19% consumed it at least once per month while 49.28% consumed it sometimes. Milk sample from Sokoto-Gudali produced significantly ($p<0.05$) higher milk fat and dry matter content but significantly ($p<0.05$) lower protein level when compared with the other cow breeds. Frying significantly ($p<0.05$) decreased the protein content of milk fat of both Bunaji and Holstein-Friesian while frying with onion had no significant ($p<0.05$) effect on the protein content of all the samples. Physicochemical analysis revealed that viscosity was significantly ($p<0.05$) higher in Bunaji when compared to both Sokoto-Gudali and Holstein-Friesian and processing methods (fried with or without onion) significantly ($p<0.05$) reduced the viscosity in samples from all the breeds. Acid value of milk fat from Bunaji was significantly ($p<0.05$) higher than those from Sokoto-Gudali and Holstein-Friesian and processing significantly ($p<0.05$) increased the acidic value in all the three cow breeds. However, Holstein-Friesian had significantly ($p<0.05$) higher saponification value and processing methods (fried with and without onion) also significantly ($p<0.05$) increased this value except in Sokoto-Gudali where fresh sample had significantly ($p<0.05$) higher value than the fried with and without onion. Bunaji milk fat had significantly ($p<0.05$) higher iodine value and processing methods significantly ($p<0.05$) increased the iodine value, however, processing significantly ($p<0.05$) decreased this value in Holstein-Friesian. Holstein-Friesian produced more saturated fatty acids than Bunaji and Sokoto-Gudali (96.23%, 91.56% and 91.01%, respectively). Linoleic acid was contained in similar quantity by both Bunaji and Sokoto-Gudali breeds. Milk fat from Holstein-Friesian possesses higher content of oleic acid (0.3%) when compared to Bunaji and Sokoto-Gudali (0.11 and 0.01%), respectively. Appreciable amount of myristoleic (1.31%) and palmitoleic acids (1.72%) were only observed in Bunaji. Fatty acids profile of milk fat differs with respect to breed of cow and processing affects the composition of the fatty acids, physicochemical properties and nutrient profile.

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LIST OF ABBREVIATIONS

%	Percentage
AV	Acid Value
BNJ	Bunaji Breed of Cow
CLA	Conjugated Linoleic Acid
FAO	Food and Agriculture Organization
GCMS	Gas Chromatography and Mass Spectrum
HLF	Holstein-Friesian Breed of Cow
IV	Iodine Value
LGA	Local Government Area
rpm	revolution per minute
NAPRI	National Animal Production Research Institute
PV	Peroxide Value
SFA	Saturated Fatty Acid
SGL	Sokoto-Gudali Breed of Cow
SV	Saponification Value
USFA	Unsaturated Fatty Acid

WHO	World Health Organization
LGA	Local Government Area
HH	Household

CHAPTER ONE

1.0 INTRODUCTION

Worldwide, fats and natural vegetable oil are increasingly becoming important in nutrition and commerce because they are sources of dietary energy, antioxidants, biofuels and raw material for industrial products. Fats are used in food, cosmetic, pharmaceutical and chemical industries. Vegetable oils account for 80% of the world's natural oils and fat supply (FAO, 2007). Milk is described as a white liquid produced by mammals from the mammary gland to feed the young ones. It is a vital type of food for over six billion human beings all over the world (Belewu, 2006). It is also a major contributor to food security as it alleviates poverty and mitigates malnutrition. Nutritionally enriched milk and its products with enhanced biological potential and without health risks are generally demanded (Baloch *et al.*, 2006; Rahman *et al.*, 2006; Khan and Zeb, 2007). For centuries, cow milk has been consumed and processed into various dairy products such as butter, cheese and ice cream. Studies have shown that addition of antioxidant nutrients like vitamin E and trehalose in the diets of dairy cows may result in milk low lipid peroxide value and greater antioxidant potential of milk (Al-mabruk *et al.*, 2004; Sympoura *et al.*, 2009; Aoki *et al.*, 2010). Lactose in milk is also used in the preparation of infant foods (Belewu, 2006). It was noted that conjugated linoleic acid (CLA) present in milk and dairy products were also found to help in lowering the risk of arterial disease, cancer, hypertension and type 2 diabetes (Pan *et al.*, 2011). Substitution of low fat dairy products for meat as a protein source could reduce the risk of type2 diabetes by 17% (Pan *et al.*, 2011). The nutrient value of milk is widely documented (Huth *et al.*, 2006). In Nigeria appropriately 90% of the dairy cattle belong to the "*Fulani*" pastoralists who process surplus fresh milk to various nutritious milk products such as Sour milk (*Nono*), Local yoghurt (*Kindirmo*), Milk fat (*Manshanu*) and West African soft cheese (*Wara*) (Adetunji and Chen, 2011).

Milk fat; being an important constituent of milk, play significant role in the economics, nutrition, flavour and physicochemical properties of milk and milk products. Milk fat is processed by collecting fresh milk and allowing it to ferment for a day or two in calabashes or rubber buckets locally. Milk fat is uniquely distinct from other fats, being the only fat containing short chain fatty acids (Kumar *et al.,* 2002). Milk fat which is commonly known as butter can be consumed alone or most importantly with other foods like "*Dambu*". "*Dambu*" is made of maize with spices, vegetable and cooked for about 50 minutes.

Milk fat production and consumption are much more practiced in the northern part of Nigeria than in any other part of the country due to its availability; however, does not appeal to some people because of its aroma and short shelf- life (Adetunji and Chen, 2009). Knowledge of the physicochemical properties will obviously enhance the consumption on a large scale. Milk fat is used as cosmetic (hair and body oil) by both rural and urban people. Therefore, the analysis of content of foods is essential for nutritional and health purposes. The present study, therefore, investigates the consumption pattern and effect of processing (fried with and without onion used traditionally to enhance flavour and extension of shelf life) on fatty acid profile of milk fat (*manshanu*) produced from milk of local cow breeds (Bunaji, Sokoto-Gudali) in Zaria and an exotic (Holstein-Friesian) breed used as reference; raised under the same management system.

1.1 Statement of Research Problem

Diet containing high saturated fatty acids has been correlated with chronic diseases of the cardiovascular system (Lichtenstein *et al.,* 1998). Metabolic studies have shown that *trans* fats have adverse effects on blood lipid levels- increasing Low Density Lipoprotein (LDL) cholesterol while decreasing High Density Lipoprotein (HDL) cholesterol (Mensink and Katan, 1992). This combined effect on the ratio of LDL to HDL cholesterol is double that of saturated

fatty acids. Dietary lipids play an important role in nutrition and health. But for decades lipids have been at the center of controversy with respect to obesity and disease such as hypertension. Diet with adequate amount of unsaturated fatty acids may have good effect on the prevention of chronic heart disease (Wayua *et al.*, 2007).

1.2 Justification

The dairy industry in most countries has challenges regarding breeding and nutritional strategy to produce milk with optimum quality for different purposes. The composition of milk largely indicates its nutritional value. Quantitatively, cow milk is the most widely produced and processed animal raw material worldwide (Mourad *et al.*, 2014). The individual caseins, especially alpha s1-casein (αs1-casein), alpha-lactalbumin (α-LA) and beta-lactoglobulin (β-Lg) are considered as major milk allergens (El-Agamy, 2007).

There is no available information on the consumption pattern, nutrient profile and physicochemical properties of cow milk fat among local breeds in Nigeria. Information on the lipid profile of cow milk fat from local cow breeds in Zaria may serve as a source of developing food composition tables to enrich existing food databases in Nigeria. This information may also serve in developing therapeutic diets for people suffering from different diseases. Therefore, a more detailed overview of milk fat composition in terms of principal components is needed to set a standard on technological properties for processing the milk fat.

Availability of information on the frequency of consumption and physicochemical properties of fresh and processed milk fat from the local cow breeds in Nigeria is very limited, hence the need for a study to be conducted to establish the frequency of consumption and effect of breeds on the composition of cow milk fat under the same management system with a view to providing up-to-date information and baseline scientific data on the physicochemical properties of milk fat from local cow breeds in Zaria, Northern Nigeria.

1.3 Aim and Objectives of the Study

1.3.1 Aim

The aim of this research is to determine the consumption pattern and effect of processing methods on fatty acid profile of milk fat (*manshanu*) produced from milk of local cow breeds (Bunaji, Sokoto-Gudali) and Holstein-Friesian available in Zaria.

1.3.2 Objectives

The specific objectives are to:

i. Determine the consumption pattern of milk fat "*Manshanu*" in Zaria Local Government Area.
ii. Compare the yield of milk fat and dry matter content of fresh milk from different cow breeds in Zaria.
iii. Determine the effect of processing methods on protein content and physicochemical properties (colour, pH, viscosity, acid, saponification, peroxide and iodine values) of milk fat from different cow breeds.
iv. Determine fatty acid profile of the milk fat from different cow breeds in Zaria.
v. Determine the effect of processing methods on fatty acid profile of milk fat from different cow breeds in Zaria.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Cow Milk

Milk, which is secreted by mammary glands, is the only food of the young mammal during the first period of its life (Webb *et al*., 1974; Hassan, 2005). The constituents of milk provide both energy and the building substances necessary for growth. Milk is an important source of all basic nutrients such as carbohydrate (lactose), fat, protein (essential amino acids), vitamins, minerals and water required by mammals including human beings (Ahmad *et al.,* 2013). Cow milk is the standard and commercially acceptable milk in which Bunaji cows breed are the principal producers (Adeneye, 1989). Studies have shown that these nutrients (lactose, fat, essential amino acids) are distributed in milk in appropriate dietary requirements (AAP, 1993). Milk from mammals such as cow is used for different nutritional purposes. For example, it is used for feeding of young ones and preparation of some nutritional products such as milk cream, butter, yogurt, milk fat and sour milk (Webb *et al*., 1974; Hassan, 2005). Milk also contains antibodies which protect the young mammal against infection (Bylund, 1995). Milk plays a tremendous role in building a healthy society and can be used as means for rural development, employment and retarding the migration of the rural population (Sarwar *et al*., 2002). The local cow breeds in Nigeria include; Bunaji and Sokoto-Gudali. Nearly 35% of dairy cows (about 70 million head) belong to the Holstein-Friesian breed worldwide; due to its low milk fat content, high average milk production (Fox, 2008) and superior ability to convert feed into protein (Buchanan, 2002). This is not an ideal situation as it can negatively affect the biodiversity and widespread use of this one breed which may put some breeds in danger of extinction (Buchanan, 2002), hence, the need to intensively study our local cow breeds. Cow milk accounted for 83% of global milk production in 2010 (FAOSTAT, 2012). Cow milk

contains more protein and minerals, especially calcium and phosphorus, than human milk (Clemens *et al.*, 2011). This is because a baby cow (calf) grows faster than a human child and hence has higher nutritive demands. The quality of protein in cow milk is high, containing a good balance of all the essential amino acids; with highest concentrations of leucine and lysine (Adesina, 2012). Cow milk contains more protein and lactose than goat milk, resulting in comparable energy contents (Asif and Samaira, 2010). The type of caseins that predominate in the cow and human milks also differs, human milk containing more β-casein, which is more susceptible to peptic hydrolysis than αs-casein, particularly αs1-casein, which predominates in cow milk (El-Agamy, 2007). The casein content of cow milk varies between breeds and cheese makers often use milk from breeds with higher k-casein (k-CN) content in their milk (Bonfatti *et al.*, 2010), probably because of its importance in the stability of the micelle and its role in dairy processing. The k-CN is also the only casein having carbohydrate residues in its constituents (Fox and Mulvihill, 1992).

2.1.1 Cow milk production and consumption in Nigeria

The state of milk production in Nigeria has been of less importance probably due to poor production incentive, poor calving percentage and poor management system (Belewu, 2006), for years when compared with the current emphasis on agriculture in general. So far with the present Government, Nigeria has been improving on milk production and in agricultural activities in general. In Nigeria, cows provide more than 90% of the total animal milk output while goats and sheep provides less than 10% and are normally kept for production of meat, hides and skin (Walshe *et al.*, 1991). Even though, their production is still based on the traditional pastoral systems due to a number of factors such as systems of dairy husbandry, breeds of cattle, milking methods, and storage system of dairy, its products (Nuru, 1988).

Local milk production in Nigeria is mainly from indigenous cattle breeds, which are kept primarily by pastoralists, most of whom are Fulani. More than 95% of the head of cattle in

Nigeria are indigenous breeds. Average milk production per cow is about 0.74 litres per day, ranging from 1.27 litres during the wet season to 0.36 litres during the dry season, these results in an estimated local milk production of roughly 450,000 tons per annum (Annatte *et al.*, 2012). Milk production under modern intensive and semi-intensive systems in Nigeria contributes only about 3% of the national output of milk. In addition, government-owned dairy plants (NAPRI Dairy Unit, Ahmadu Bello University, Zaria), private dairy firms (Abdullahi Dikko Inde Farm Shika-Zaria) have sprung up over the years. However, virtually all the dairy firms in Nigeria have either shut down or are having serious problems (Annatte *et al.*, 2012).

2.1.2 Cow milk composition

Milk is a complex fluid which is composed of several separate chemical compounds (Adesina, 2012). Milk is a considerable source of products whose composition varies. Four components are dominant in quantitative terms: water, fat, protein and carbohydrate; while the minor components are minerals, enzymes, vitamins, and dissolved gases (Adesina, 2012; Mourad *et al.*, 2014). It satisfies the demand of the consumer who seeks more and more innovative products with consistent quality. Therefore, it is necessary to utilize all the riches of this raw material, which is both simple in appearance and complex in composition. Milk with higher content of fat and protein generally commands high premium (Tolusic *et al*., 2006).

Among all nutrients, water is the one that occurs in the highest quantity, and milk contains a lot of water (88.5%), this amount of water is controlled by the amount of carbohydrate synthesized by the secretory cells of the mammary gland (Oladapo and Ogunekun, 2015). Fat in milk is the main source of energy. Polyunsaturated fatty acids which are also present in cow milk are essential for metabolism in human (Grand-Pierre *et al.*, 1988). Most unsaturated fats in our diet are in the cis form, and lower proportions are in the *trans* form (Stender and Dyerbery, 2003).

The proteins in cow milk contain the essential amino acids, and elements that our bodies cannot produce (Ahmad *et al.,* 2013). Cow milk proteins have roughly the same composition as the egg protein, except for the amounts of methionine and cystine, which are significantly lower (Ahmad *et al.,* 2013). Indeed, the sulfur amino acids are the limiting factors in milk. Casein and complex cow milk protein contain good proportion of all amino acids essential for growth and maintenance (Konte, 1999).

Carbohydrate in milk is formed by the union of one molecule of D-galactose and one molecule of D-glucose. It has a β-galactoside 1, 4 bonds and is a 4-D-glucopyranosyl-β-D-galactopyranose. Concentration of sugar from cow milk varies slightly (4.53 to 4.83g /100g) (Oladapo and Ogunekun, 2015) contrary to the concentration of fat which cannot be easily modified by feeding and dairy breed. It plays a role in fermented milk production. The amount of lactic acid produced by lactic acid bacteria in a fermented milk product depends not only on the bacterium itself and operating parameters, but also on the available amount of lactose fermenting bacteria (Oladapo and Ogunekun, 2015). Enzymes are specific globular proteins produced by living cells and each enzyme has isoelectric point which is susceptible to various denaturing agents such as pH change, temperature, ionic strength, organic solvent (Carole and Vignola, 2002).

Minerals play an important role in the structural organization of casein micelles, the main minerals present in milk are Ca, Na, Mg, P, Cl and K (Oladapo and Ogunekun, 2015). Levels of vitamins A, D and E are variable; depending on the season as there is a slight increase during the pasture season (Oladapo and Ogunekun, 2015). Vitamins are fat soluble, so are found in fat and can be lost during skimming. Other vitamins are water soluble and are found in the serum. In the case of vitamin C, it is present in small quantities in fresh milk and is destroyed by contact with air and also during pasteurization (Schrodes, 1982). The milk processing techniques can significantly change the amount of vitamin C (Florence, 2010).

2.1.3 Factors affecting cow milk composition

Cow milk composition like other animal milks, is affected by various factors, including breed differences, stage of lactation, number of calving, seasonal variations, age, health, diet, management system and herd size of animal (cow) (Laben, 1963; Bansal *et al.*, 2003; Walker, Dunshea and Doyle, 2004; Jenkins and McGuire, 2006).

2.1.4 Nutritional values of cow milk

Cow milk is a very good source of dietary fat, carbohydrate, protein and other nutrients (FAO and WHO, 2001). The high protein content of cow milk is one reason why unmodified cow milk is not recommended for infants less than 12 months of age. The recommended safety level of protein intake for children 10 years of age is 26g/day (FAO and WHO, 2001). Cow milk is also considered not a good source of iron, therefore, it is not recommended in the complementary feeding of infants less than one-year-old. In addition, feeding cow milk to infants can lead to intestinal bleeding and loss of iron (Ziegler, 2007). The high calcium and casein contents in cow milks can also inhibit the absorption of dietary non-heme iron (Ziegler, 2007). The content of sodium in cow milk is low (Clemens *et al.*, 2011). Cow milk contains significant amounts of selenium (11µg/100g), and even 250ml of cow milk can provides the recommended nutrient intake (RNI) of 17µg for a 1–3 years old child (Clemens *et al.*, 2011). Cow milk is an adequate source of riboflavin (Clemens *et al.*, 2011). 500ml of cow milk can provides the RNI (0.5mg/day) of riboflavin. Cow milk is a good source of the B Vitamins, including vitamin B_{12} (Platt, 1964). Individual Saturated Fatty Acid (SFA) has different effects on the concentration of lipoprotein cholesterol fractions, with lauric acid (C12:0), myristic acid (C14:0) and palmitic acid (C16:0) increasing LDL cholesterol, while stearic acid (C18:0) has no effect (FAO and WHO, 2010). There is convincing evidence that substituting SFA (C12:0 – C16:0) with Poly Unsaturated Fatty Acid (PUFA) decreases LDL cholesterol concentration and the HDL cholesterol ratio (FAO and WHO, 2010). A similar but lesser effect is achieved by

replacing these SFA with Mono Unsaturated Fatty Acid (MUFA) (FAO and WHO, 2010). *Trans*-Fatty Acid (tFA) contents of up to 3–6g/100g total Fatty Acid (FA) have been reported in cow milk (LeDoux *et al.*, 2002; Rodríguez *et al*., 2009). However, these values depend on the diet of the cow, with values between 0.1- 2.2g of CLA/100g total FA, the amount varying with various factors including feed, with values as high as 3.3g/100g total FA reported in milk from grass fed cows (Jutzeler and Colombani, 2010). The most biologically active form of CLA was C18: cis-9, *trans*-11 (c9, t11-CLA) (Jensen, 2002), which represents more than 90 percent of CLA in ruminant milk fat (Savoini *et al*., 2010).

2.1.5 Health benefits of cow milk

Milk and fermented dairy products have a long history of use, as far back as the seventh millennium BC (Evershed *et al.*, 2008). Milk is a major source of dietary energy, protein and fat, contributing on average 134kcal of energy/capita per day, 8g of protein per day and 7.3g of fat per day (FAOSTAT, 2012). Milk also serve as protector against oxidative stress (Hunter *et al.*, 2012). Cow milk has an average water content ranging from 87.17 to 87.42% (Adesina, 2012). The main carbohydrate (lactose) in milk is involved in the intestinal absorption of calcium, magnesium and phosphorus, and the utilization of vitamin D (Park *et al*., 2007). There is very good evidence that calcium and vitamin D, two important constituents of milk and milk products, play key roles with respect to attaining peak bone mass and preventing osteoporosis and fractures (Park *et al*., 2007). Emerging evidence also indicates that milk products are better than calcium and/or vitamin D supplements in this respect, indicating an important role for other nutrients (Heaney, 2000). Evidence also demonstrates that other nutrients found in milk products may also be involved in bone health; they include: protein, potassium, magnesium, phosphorus, vitamin B_{12}, vitamin K, and zinc (Heaney, 2000). Although the mechanisms by which milk products may regulate blood pressure remain to be fully understood, calcium is

thought to be one of the main nutrients responsible for the impact of milk products on blood pressure control (Martin *et al.,* 2002). High concentrations of intracellular calcium increases smooth muscle tone, vascular resistance and responsiveness to signals from the nervous system, which all elevate blood pressure. When calcium blood levels drop, the above mechanism described tends to release more calcium than necessary, this then increases intracellular calcium, causing high blood pressure. Therefore, daily adequate intake of calcium especially from milk ensures a normal flow of calcium without using the bones as an emergency source of calcium (Martin *et al.,* 2002).

2.2 Cow Milk Fat

Cow milk fat commonly known as 'Manshanu' in Hausa language and "ghee" in India; is important traditional cooking oil most common in the northern Nigeria. It is sold mostly together with "*Fura*" and "*Nono*" by the Fulani pastoralists (Annatte *et al.,* 2012). Milk fatty acids originate either from microbial activity in the rumen, and *trans*ported to the secretory cells via the blood and lymph, or from synthesis in the secretory cells (Grummer, 1991). The major fatty acids found in milk are: long chain (myristic, C14:0 10.7%, palmitic, C16:0 27.6%, stearic, C18:0 10.1%, and oleic C18:1 26.0%) and short chain (butyric, C4:0 3.6%, caproic, C6:0 2.3%, caprylic, C8:0 1.3% and capric, C10:0 2.7%) (FAO, 1998). Butyric acid is specific for milk fat of ruminant animals and is responsible for the rancid flavour when it is cleaved from glycerol by lipase action. Oleic acid is the most abundant unsaturated fatty acid in milk with one double bond. Triglycerides account for more than 95% of milk fat (Guetouache *et al.*, 2014). The small amounts of mono, diglycerides and free fatty acids in fresh milk may be a product of early lipolysis or incomplete synthesis. Other classes of lipids include phospholipids (0.2-1.0%) which are mainly associated with the fat globule membrane, and trace amount of cholesterol which is mostly located in the fat globule core (FAO, 1998).

2.2.1 General description of cow milk fat

Cow milk fat is usually a semi solid substance (butter) extracted from cow's milk with a white or golden yellow colour in appearance and is consumed commonly by some members of the society in Africa including Nigeria and Middle Eastern countries (Abdel Moneim *et al.,* 2013**)**. It has an average shelf life of 2-3days when stored under ambient temperature (Adetunji and Chen, 2009). However, milk fat can have a longer shelf life, if refrigerated and at room temperature (http://whatscookingamerica.net, 2010), especially when fried with or without onion.

Plate 1.1: Photograph of Manshanu (Milk Fat)

2.2.2 Uses of cow milk fat

Fermented milk products; example milk fat fulfills multiple purpose in both rural and urban areas (O' Mahony, 1988). It is consumed as foods and the market value and storage life are improved over that of raw milk (Motarjemi and Nout, 1995). It is also used as hair and body oil in rural and urban areas. Locally, cow milk fat is also used for treating diseases associated with cold.

2.2.3 Nutritional benefits of cow milk fat

Dietary lipids play an important role in nutrition and health. Lipids supply calories and fatty acids which act as carriers of fat soluble vitamins, and increase the palatability of the food (Wayua *et al.,* 2007). Nutritionally enriched milk and its products; for example, milk fat with enhanced biological potential and without health risks are generally demanded (Baloch *et al*., 2006; Rahman *et al*., 2006; Khan and Zeb, 2007).

2.2.4 Health benefits of cow milk fat

In recent decades, technological innovations have led to a wide variety of dairy products, some of which have had components, such as fat and lactose, removed or contents reduced and others of which have been fortified with components, such as iron, sterols and vitamin D. When considering the health impact of dairy foods, it is critical to evaluate the impact of the food as a whole, and not just the individual nutrients. It has been acclaimed both by popular wisdom and some researcher's findings as being more nutritious and health promoting than fresh milk (Akabanda *et al.,* 2010).

2.2.5 Fatty acid profile of raw cow milk fat

Generally, cow milk contains between three 3-4g of fat in every 100g of milk. Most of the commercially processed milk products consumed now contains a standardized fat content of around 3.5g/100g. Cow milk contains a similar proportion of SFA as that of camel of which about 40 percent are lauric to palmitic (C12:0–C16:0) (Wayua *et al.,* 2007). Milk fat has been reported to contain sixty-four (64) FA, the predominant ones being oleic (18:1 ω-9) (30%), palmitic C16:0 (24%), stearic C18:0 (13%) and myristic C14:0 (9%), with 62% total saturated, 33% total unsaturated and 4% total polyunsaturated fatty acids (Herb *et al.,* 1962). The CLA content in cow milk is generally reported to vary from 0.1- 2.2g/100g total FA depending on animal and breed, season, region, farming system and diet (Elgersma *et al*., 2006). For

example, milk from the Mafriwal cow breed was shown to contain a significantly ($p<0.05$) higher percentage of CLA than Jersey cow milk (0.35g/100g total FA verses 0.23g/100g total FA) (Yassir *et al*., 2010). This has possible implications with regard to promoting cow breeds with a higher CLA content in their milk. Levels of water soluble vitamins in human milk reflect maternal levels and depend on the mother's diet, but these vitamins are synthesized within the body of the cow and levels are not diet dependent in cow milk.

2.3 Physical Properties of Milk Fat

2.3.1 Colour

The color of milk is perceived by consumers to be indicative of purity and richness. Its white color is due to the scattering of reflected light by the inherent ultramicroscopic particles, fat globules, colloidal casein micelles, and calcium phosphate (Goff and Hill, 1993). The intensity of white colour is directly proportional to the size and number of particles in suspension. Homogenization increases the surface area of fat as a result of breaking up of larger globules. Accordingly, homogenized milk and cream are whiter than their un-homogenized counterparts. Lack of fat globules gives skim milk a blue tinge. Cow's milk contains the pigments carotene and xanthophyll, which tend to give a golden yellow colour to the milk fat (Goff and Hill, 1993).

2.3.2 Viscosity

Viscosity means resistance to flow and direct measurement of a fluid's quality (Abbas *et al.*, 2010). It is essential to measure this parameter because a change in viscosity can indicate a fundamental change in the sample under investigations. Viscosity measurement is often an extraordinarily sensitive measurement of another property such as solids content and crystal concentration (Jethra, 1994). The viscosity characteristics of food products influence many aspects of the fluid performance during processing such as (pumpability, emulsion formation,

flow into molds and formability) and the quality of liquid products such as (texture, flavour release, stability and appearance) (Abbas *et al.,* 2010). The viscosity of dairy products such as cream, ice-cream, yoghurt (full cream or skimmed milk), cakes, biscuit sweets and confectionary can creates the impression of "richness" to the consumer. From an organoleptic standpoint, viscosity contributes to mouth feel and flavor release. The casein micelles of milk contribute more to the viscosity of milk than any other constituent. Viscosity varies not only with changes in the physical nature of fat but also with the hydration of proteins. Alterations in the size of any dispersed constituents result in viscosity changes. When fat globules are greatly subdivided by homogenization, an increase in viscosity is observed. An increase in temperature causes a marked reduction of viscosity. For example, at 20°C, milk is about half as viscous as at 0°C and at 40°C is approximately one-third of the value at 0°C.

2.3.3 pH

The pH is short form for the potential of hydrogen. It is a measure of the acidity or alkalinity of a substance. pH is the most common of all analytical measurements in industrial processing and since it is a direct measure of acid content, it clearly plays an important role in food processing. Among the reasons for measuring pH in food processing include: to produce products with consistent well defined properties, to avoid spoilage of food substance and to meet regulatory requirements. Variations of pH can impact flavor, consistency and shelf-life. Milk and dairy products have pH values of around 6.8 and it is tested for impurities and signs of infection upon collection as well as at point of delivery. In processes such as sterilization, pH is checked since a lower value helps to speed up the process. However, lower pH levels can indicate that the cattle infections with diseases such as mamites. Controlling the pH value is very important in butter manufacturing processes. For example, cream is cooled after pasteurization at a very strict pH value of 6.70 to 6.85 to generate sweet butter. In order to manufacture sour butter, citric acid extracts are added to acidify the cream to 4.6-5.0 pH value.

2.4 Chemical Properties of Milk Fat

2.4.1 Acid value

The Acid Value (AV) is defined as the number of milligrams of potassium hydroxide required to neutralize the fatty acids present in one gram of fat. It is a relative measure of rancidity as free fatty acids are normally formed during decomposition of oils glycerides. The acid content is given by the quantity of free fatty acid**s** deriving from the hydrolytic deterioration (ranciding) of the triacylglycerols (Piotr *et al.*, 2008). This change occurs under unsuitable conditions of treatment and preservation of the fats and thus the acid value represents a basic indicator of the genuineness of the product. Fats with high water content, such as butter, are more susceptible to hydrolysis and they can alter more easily, assuming the typical unpleasant smell and taste.

The oxidation of fats is an important deteriorative reaction with significant commercial implications in term of product value (Yildiz *et al.*, 2002). The initial oxidation products that accumulate are hydroperoxides, which may subsequently break down to form lower-molecular weight compounds such as alcohols, aldehydes, free fatty acid**s** and ketones, leading to autoxidative rancidity. The acid value may be overestimated if other acid components are present in the system, e.g. amino acids or acid phosphates (Piotr *et al.*, 2008). The acid value is often a good measure of the breakdown of the triglycerides into free fatty acids, which has an adverse effect on the quality of many lipids. In general, it gives an indication about edibility of the lipid.

2.4.2 Saponification value

The Saponification Value (SV) is the number of milligram of potassium hydroxide required to neutralize one gram of the fat or oil. The SV is a measure of the average molecular weight of the triglycerides in a sample. Saponification is the process of breaking down a neutral fat into

glycerol and fatty acids by treatment with alkali. The smaller the SV the larger the average molecular weights of the triglycerides present i.e. SV is inversely proportional to the mean molecular weight of fatty acids (or chain length). The saponification value is an index of mean molecular weight of the fatty acids of glycerides comprising a fat.

2.4.3 Peroxide value

The Peroxide Value (PV) is an indicator of products of primary oxidation and thus measures the degree of oxidation but not the stability or shelf-life of a fat. The acceptability of milk fat largely depends on the extent to which the oxidative deterioration has occurred. It is generally considered that the first product form by oxidation of an oil or fat is a hydroperoxide. The peroxides further decompose to secondary oxidation products (aldehydes and ketones) which impart off flavor in milk fat. The usual method of assessment of rancidity in milk fat is by determination of PV which is reported in units of miliequivalents of peroxide oxygen per kg of fat or ml of 0.002N sodium thiosulphate per gram of sample.

2.4.4 Iodine value

The Iodine Value (IV) is the number of grams of iodine absorbed by hundred grams of the fat or oil when determined using Wijs solution. Iodine value is directly proportional to the degree of unsaturation (number of double bonds.) and inversely proportional to the melting point of lipid. The iodine value is a measure of the amount of unsaturation in a fat sample (Travnicek *et al.,* 2006). An increase in IV indicates high susceptibility of lipid to oxidative rancidity due to high degree of unsaturation.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Materials

3.1.1 Chemicals and reagents

Chemicals and reagents used were of analytical grade and were purchased from reputable Companies.

3.1.2 Cow breeds

Two local breeds of cow that are common in Zaria (Sokoto-Gudali and Bunaji) and an exotic breed (Holstein-Friesian) under the same grazing and general management system housed at National Animal Production Research Institute (NAPRI) Zaria were used for the study. These breeds of cow were identified by specialist at NAPRI.

3.2 Methods

3.2.1 Field Survey to Determine Pattern of Milk Fat Consumption in Zaria LGA

3.2.1.1 Study area

Zaria Local Government is one of the 23 Local Government Areas in Kaduna State. Its headquarters is in Zaria city. Zaria has two distinct seasons: the dry season (October to March) and wet season (April to September). Mean annual rainfall is about 1,000mm but inter-annual fluctuation may be high. Mean monthly temperature is about 27^{o}C but it is highest between the months of March and May, which represent the hot dry period. It is lowest in December and January reaching about 22^{o}C (Kowal and Kassam, 1978). It has thirteen political wards and lies on the geographical coordinates of 11^{0} 04^{1}N 7^{0} 42^{1}E. It has a population of 408,198 at the 2006 census and covers an area of 300 km^{2}.

3.2.1.2 Subjects

The subjects for the research are the household caregivers in the selected communities in Zaria local Government Area of Kaduna State, Nigeria.

3.2.1.3 Sample size

The sample size was determined using the formula below:

$$n = \frac{t^2 \times p\,(1-p)}{M^2}$$

Where: n is required sample size, t is the confidence level at 95% (standard value of 1.96), p is the proportion in the target population estimated to have a particular characteristics set at 0.5 and M is the margin of error at 5% (standard value of 0.05).

$$n = \frac{1.96^2 \times 0.5\,(1-0.5)}{0.05^2}$$

$$n = \frac{3.8416 \times 0.5\,(0.5)}{2.5\times10^{-3}}$$

$$n = \frac{0.9604 \times 1000}{2.5}$$

$$n = \frac{960.4 \times 1000}{2.5}$$

n= 384.16

But n was adjusted to 400 for sample sampling defect and non-response

3.2.1.4 Household sampling

A multistage sampling technique was adopted for this study:

i. The local government wards were stratified into north, south, east and west
ii. Then two wards were selected from each of the stratified area
iii. Using a Table of random number generator two communities per ward were selected, making a total of eight communities which were then stratified into north and south

iv. The number of households required per community were selected using probability proportion to size
v. The households in the selected communities were listed and the eligible ones were noted. The number of eligible households required per community were selected using probability proportion to size based on the calculated sample size
vi. The numbers of required households were randomly selected.

3.2.1.5 Field data collection

Data were collected on family composition, how often each household consumed this dairy product, how much households consumed milk fat during the weeks before the date of interview, from where households obtained the product, the form in which the product was used and method of preparation. All that information was collected using semi-structured validated questionnaire (Appendix 1) by eight women specially recruited and trained for the field data collection.

3.2.2 Determination of Nutrients Profile from Cow Milk

3.2.2.1 Collection of cow milk sample

Fresh milk samples were collected using cleaned hand in a sterile container from at least two randomly selected cows from each breed herd and appropriately labeled per breed per herd at National Animal Production Research Institute Shika-Zaria.

3.2.2.2 Determination of dry matter

Immediately after the collection of milk, dry matter analysis was done on each milk sample from selected cow breeds using the method described by AOAC, (1990). Fresh milk sample for each cow breed was thoroughly mixed using wooden stirrer and one milliliter (1ml) was transferred to pre-weighed and dried flat bottom crucible. The milk samples were dried in a

hot air oven (Model- DHG-9030A made in England) at 102^{o}C to a constant weight. Finally, the dried samples were taken out of the oven and placed in desicator to cool at room temperature. Then, samples were weighed again and dry matter content was calculated using the formula of Richardson (1985):

$$\text{Dry mater (mg/ml)} = \frac{(\text{Crucible weight + oven dry sample weight}) - \text{crucible weight}}{\text{Original sample weight}} \times 100$$

3.2.2.3 Fermentation of fresh milk and preparation of milk fat

Inoculum (milk from fermented fresh milk), starter culture obtained from dairy unit NAPRI Shika-Zaria was added to fresh cow milk and fermentation process was allowed to proceed for overnight to produce fermented milk. Then the fat was removed by centrifuging properly the whole milk at 2,500 rpm for 30 minutes. The collected butter was then boiled to remove excess water to obtain the milk fat as described by Abdel Monein *et al.* (2013).

3.2.2.3.1 Sample processing (frying with and without onion)

Exactly 150g of the milk fat samples from each cow breed were processed. The processing with onion was carried out by heating the fat with 7.35g of the onion in a stainless steel vessel on a plate at 105°C for 15 minutes. The same conditions of temperature and time were also used for the processing without onion and both samples were kept in a refrigerator till when needed for analysis.

3.2.2.3.2 Determination of crude protein

Total crude protein content of the milk fat samples was determined according to the method described by Kjeldahl (1983). For digestion, 1.5g of each sample was weighed into 300ml Kjeldahl flask. Accurately, 25ml tetraoxosulphate (vi) acid (H_2SO_4) and 3g mixed catalyst was added into the Kjeldahl flask. The flask was then *trans*ferred to the Kjeldahl digestion

apparatus. The sample was digested until a clean colour was obtained. The digest was cooled and diluted to 100ml with distilled water.

For distillation, 20ml of the diluted digest was measured into a 500ml Kjeldahl flask containing anti bumping chips and 40ml of 40% NaOH was slowly added by the side of the flask. A 250ml conical flask containing a mixture of 50ml of 2% Boric acid and 4 drops of mixed indicator (phenolphthalein) was added in order to trap the ammonia librated. The conical flask and the Kjeldahl flask were then placed on the Kjeldahl distillation apparatus, with the tubes inserted into the conical flask and the Kjeldahl flask. The flask was heated to distill out ammonia evolved. The distillate was collected into the boric acid solution. From the point when the boric acid turned green and allowed for 10 minutes for complete ammonia distillation present in the digest. Finally, the distillate was titrated with 0.1M HCl and a blank was also set alongside. Nitrogen content was calculated and multiplied with conversion factor (6.25); to get the crude protein content of each sample. The percentage of nitrogen and crude protein were calculated as follows:

$$N\ (\%) = \frac{Vs \times Vb \times M \times 14}{Va \times \text{weight sample (mg)}} \times 100$$

$$CP\ (\%) = N_2\ (\%) \times 6.25$$

Where, N_2 (%) = percentage nitrogen by weight; Vs= total volume of diluted digest; Vb= titre volume of HCl used; Va= aliquot volume distilled; M= actual molarity of acid; CP (%)= Percentage of crude protein, 6.25 = conversion factor.

3.2.3 Determination of Physical Properties of Milk Fat

3.2.3.1 Colour

The colour was determined using a Lovibond apparatus (Tintometer model E, S. No.5064E England) according to the procedure described by ISI (1984). The milk fat sample from each

cow breed was melted and the oil was filtered through filter paper in order to remove impurities. The glass cell was cleaned using carbon tetrachloride and was allowed to dry. The glass cell was filled with the oil sample and placed in the tintometer. The colour observed was matched with sliding red, yellow and blue colours. Finally, the colour was reported in terms of Lovibond units as follows:

colour reading = (aY+5bR)

Where: a = sum total of the various yellow slides (Y) used
b = sum total of the various red (R) slides used
Y+ 5R = mode of expressing the colour of light coloured oils

3.2.3.2 pH

The pH of the milk fat samples was determined using a digital pH meter (JENWAY 3505) based on the procedure described by O' Connor (1995). The digital pH meter was calibrated with pH 4 and 7 buffers. The milk fat sample of each cow breed was melted and allowed to cool before taking the value.

3.2.3.3 Viscosity

The viscosity of milk fat was determined as described by the AOAC (2000) method using a Brookfield LVDV-II viscometer (Brookfield Engineering Laboratories Ltd., Middleboro, MA). The milk fat of a particular sample was placed in a clean dry container and heated to 60^{o}C using hot plate. The viscometer was powered and the probe on it was inserted into the milk fat sample. The speed of the viscometer was set at 50 rpm, still on the hot plate, the spindle in the viscometer was inserted into the sample and run for viscosity and this was done in triplicate and the mean was calculated. The same procedure was done on the remaining samples.

3.2.4 Determination of Chemical Properties of Milk Fat

3.2.4.1 Acid value

The Acid Value (AV) was determined as described by IUPAC (1979) method. A solvent mixture of 25ml (95%) ethanol and 25ml diethyl ether was neutralized with 0.1M ethanolic KOH using phenolphthalein as indicator. Exactly, 4g of milk fat sample was dissolved in the neutralized solvent mixture and titrated with 0.1M ethanolic KOH. The AV was calculated according to the formula below:

$$\text{AV (mgKOH/g fat)} = \frac{V \times T \times 100}{M}$$

Where: V = Volume of KOH, T = Concentration of ethanolic KOH and M = Mass (g) of test sample

3.2.4.2 Saponification value

The Saponification Value (SV) was determined using the method described by IUPAC (1979). Exactly 5g of each milk fat sample was weighed into a round neck conical flask and 25ml ethanolic 0.5M KOH was added. Then, few drops of antibumping agent were also added; the mixture was refluxed and placed on a water bath at 35^{O}C for one hour. Exactly 0.5ml of phenolphthalein was added and titrated with 0.5M HCl solution. A blank test was also set simultaneously under the same condition. SV was calculated according to the formula below:

$$\text{S.V (mgKOH/g fat)} = \frac{56.1 \times T \times (V_1 - V_2)}{M}$$

Where: V_1 = Volume of HCl for blank, V_2= Volume of HCl for test sample, T = Concentration of HCl and M = Mass (g) of test sample

3.2.4.3 Peroxide value

The Peroxide Value (PV) was determined using IUPAC (1979) method. Exactly 2g each of the milk fat samples were weighed into ground neck flask and 10ml chloroform was added to dissolve the milk fat. This was followed by the addition of 15ml acetic acid and 1ml of 15% KI solution. The mixture was shaken and kept in the dark for 5 minutes. Twenty-five milliliters (25ml) distilled water was added and titrated with 0.002M sodium thiosulphate. Peroxide value was calculated according to the formula below:

$$\text{PV } \textbf{(g/}100\text{g fat}\textbf{)} = \frac{V \times T \times 100}{M}$$

Where: V = Volume of sodium thiosulphate, T = Concentration of sodium thiosulphate and M = Mass (g) of test sample.

3.2.4.4 Iodine value

The Iodine Value (IV) was determined using Wijs method as described by IUPAC (1979). Accurately 0.35g of each milk fat sample was weighed into clean dry round neck conical flask containing 20ml of Carbon tetrachloride (CCl_4) and 25ml Wijs reagent was added; mixture were shaken and placed in the dark for one hour. After the set time, 20ml of 10% KI and 150ml distilled water were added mixed well. The mixture was titrated against 0.1M sodium thiosulphate using 1% starch solution as indicator. A blank test was set simultaneously under the same condition. IV was calculated according to the formula below:

$$\text{IV (g/100g fat)} = \frac{12.69 \times T \times (V_1 - V_2)}{M}$$

Where: V_1 = Volume of sodium thiosulphate for blank, V_2= Volume of sodium thiosulphate for test sample, T = Concentration of sodium thiosulphate and M = Mass of test sample

3.2.5 Determination of Fatty Acid Profile

3.2.5.1 Preparation of fatty acid methyl esters

The milk fat extracted was methylated weighing 0.5g of each sample into separate conical flasks. Exactly, 6ml of methanolic NaOH (0.1 M of NaOH in methanol) was added into each flask containing the sample and refluxed for 30 minutes followed by addition of 10ml of 0.5% HCl and then refluxed for another 10 minutes. After this, 10ml of n-hexane was also added to each flask and allowed to stay for 2 minutes and then cooled. Precisely, 10ml of distilled water was added to each flask, after which the fat was separated using separating funnel.

3.2.5.2 Fatty acids profile

The methylated fat was subjected to gas chromatography and mass spectrophotometer using GC-MS QP2010 PLUS (Shidmazu, Japan), 0.25µ film thickness (Restek, USA). The column temperature used was as follows: 70^{o} C rise at 10^{o}C per minute to 240^{o}C, hold for 4 minutes, raise at 15^{o}C per minute to 280^{o}C, hold for 5 minutes, with an injection temperature of 250^{o}C. The carrier gas used was Helium with flow rate of 40.8ml per minute. The detector was quadrupole mass spectrometer with EI ionization at 70ev in full scan mode (Adams *et al.*, 2001). The fatty acids were identified by comparing their retention times with those of standards and the content of fatty acids was expressed as percentage of total fatty acids.

3.3 Statistical Analysis

The results were expressed as percentage and mean ± standard deviation (SD). Data obtained were analyzed by analysis of variance (ANOVA) using statistical package for the social sciences (SPSS) version 20.0 software. The differences between samples were compared using Duncan multiple range test. P value less than 0.05 ($p< 0.05$) was considered as significant.

CHAPTER FOUR

4.0 RESULTS

4.1 Consumption Pattern of Milk Fat (*Manshanu*) in Zaria LGA

The results of milk fat consumption pattern are presented in Table 4.1. The result shows that (87.69%) of the sampled households consumed milk fat during the period covered by the survey. One out of five households of the 398 households, (87.69%) consumed milk fat two or more times per week with at least 35.5% consuming it at least once a week.

4.2 Fat Yield from Milk of Different Cow Breeds in Zaria

Result of the yield of milk fat from the local cow breeds in Zaria is presented in Figure 4.1. Sokoto-Gudali had significantly ($p<0.05$) higher mass of milk fat than the other two cow breeds. Holstein-Friesian which is used as standard had the least mass. Breed had effect on the quantity of milk fat and led to a significantly ($p<0.05$) higher value (89.62±0.20g/L) in Sokoto-Gudali compared to Bunaji (87.63±0.17g/L) and Holstein-Friesian (78.72±0.38g/L).

4.3 Dry Matter Content of Milk from Different Cow Breeds in Zaria

The mean dry matter content of milk samples collected from the three cow breeds is presented in Table 4.2. The result shows that Sokoto-Gudali had significantly ($p<0.05$) higher level of dry matter content. There was a significant ($p<0.05$) reduction in the level of dry matter content for sample from Holstein-Friesian compared to the two indigenous cow breeds (Sokoto-Gudali and Bunaji).

Table 4.1: Consumption Pattern of Milk Fat (*Manshanu*) in Zaria LGA of Kaduna State

Consumption Pattern	**Number (n = 398)**	**Percentage**
Household Consuming Milk Fat	349	87.69
Frequency of consumption		
Two or more times per week	72	20.63
At least once per week	52	14.90
Two or more per month	24	06.88
At least once per month	29	08.31
Sometimes	172	49.28

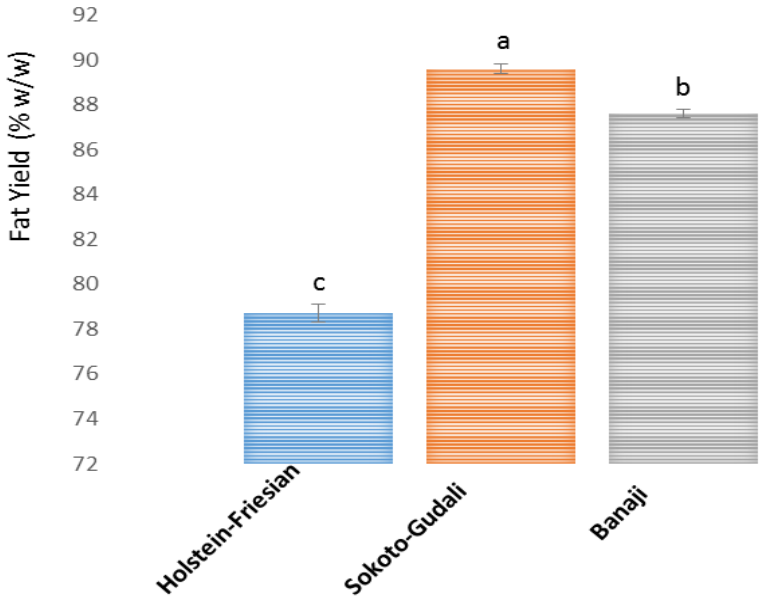

Figure 4.1: Fat Yield from Milk of Different Cow Breeds in Zaria

Values are expressed as mean ± standard deviation of three determinations.
Means with different alphabet are significantly different ($p<0.05$).

Table 4.2: Dry Matter Content of Milk from Different Cow Breeds in Zaria

COW BREEDS	DRY MATTER (mg/ml)
Holstein-Friesian	117.78 ± 3.85^{a}
Bunaji	164.44 ± 7.70^{b}
Sokoto-Gudali	182.22 ± 7.70^{c}

Values are expressed as mean ± standard deviations of three determinations. Means with different superscript down the columns are significantly different ($p<0.05$).

4.4. Effect of Processing Method on Protein Content of Milk Fat from Different Cow Breeds in Zaria

Effect of processing method on protein content of milk fat from different cow breeds in Zaria is presented in Table 4.3. The result show that fresh milk fat from Bunaji and Holstein-Friesian had significantly ($p< 0.05$) higher protein content of 3.57±0.16 and 3.41±0.14 respectively, compared to milk fat from Sokoto-Gudali (1.76±0.36). There was a significant ($p< 0.05$) reduction in the levels of protein for both Bunaji and Holstein-Friesian after frying without onion. However, significant ($p>0.05$) difference was not observed for both fresh and fried with onion samples from all the cow breeds.

4.5 Effect of Processing method on Physical Properties of Milk Fat from Different Cow Breeds in Zaria

Effect processing method on physical properties of milk fat is presented in Table 4.4.

4.5.1 Colour

The result shows that local cow breeds (Sokoto-Gudali and Bunaji) had different colour of milk fat sample compared with the exotic (Holstein-Friesian) cow breed, and that processing method had no effect on the colour of all the samples from the local cow breeds while sample from exotic breed indicated effect of colour change as a result of processing method.

4.5.2 Viscosity

The result show that Bunaji cow breed had significant ($p< 0.05$) higher viscosity value of milk fat compared with Holstein-Friesian and Sokoto-Gudali respectively. Decrease in initial viscosity was observed from raw to fried samples of the three cow breeds is an indication that processing method had effect on viscosity. However, when samples from the three breeds were fried with onion, the values tend to increase significantly ($p< 0.05$) except in sample from Bunaji cow breed.

4.5.3 pH

The result for pH obtained indicates that sample from Holstein-Friesian had significantly ($p< 0.05$) higher pH value compared with the local breeds. However, sample from Sokoto-Gudali show a significant ($p< 0.05$) pH value compared with Bunaji. There was significant ($p< 0.05$) decrease between fresh and processed samples except in sample from Bunaji, which did not differ significantly ($p< 0.05$). The average pH from Holstein- Friesian was significantly ($p< 0.05$) higher than those from the local cow breeds except in the sample processed with onion in which in all the values differ significantly ($p< 0.05$).

4.6 Effect of Processing Method on Chemical Properties of Milk Fat from Different Cow Breeds in Zaria

Effect of processing method on chemical properties of milk fat is presented in Table 4.5.

4.6.1 Acid value

The results show that fresh milk fat from Bunaji (BNJ) had significantly ($p< 0.05$) higher acid value than Sokoto-Gudali and Holstein-Friesian. The acid value obtained from all the three cow breeds shows a significant ($p< 0.05$) difference between the raw and fried samples of all the samples. However, significant ($p< 0.05$) increase was also observed in the samples fried with onion in all the breeds. This shows that processing method significantly increased acid value in all the samples. In addition, result obtained on samples from Sokoto-Gudali indicated that frying with onion significantly ($p< 0.05$) increases its acid value when compared with samples from Bunaji and Holstein-Friesian.

4.6.2 Saponification value

The result on saponification value shows that fresh milk sample from Holstein-Friesian had significantly ($p< 0.05$) higher saponification value. The result obtained from all the three cow

breeds show significant ($p < 0.05$) difference in saponification between fresh and fried without onion samples. However, a significant ($p < 0.05$) increase was also observed in the milk fat samples fried with onion except in Sokoto-Gudali where significant ($p < 0.05$) reduction was observed. This shows that processing significantly increased saponification value in all the samples.

4.6.3 Peroxide value

The result for peroxide value shows that there is no significantly ($p > 0.05$) difference in all the fresh milk fat samples from the three cow breeds (Table 4.5). However, there was significant ($p < 0.05$) increase in the peroxide value of all samples after processing. This indicates that processing led to increase peroxide except in Sokoto-Gudali where significant ($p < 0.05$) decrease was observed. This shows that processing significantly ($p < 0.05$) increased peroxide value especially in Holstein-Friesian and Bunaji breeds.

4.6.4 Iodine value

The iodine values of raw and processed milk fat are presented in Figure 4.2. The results show that Bunaji had significantly ($p < 0.05$) increase iodine value compared with the rest of the cow breeds. The iodine value obtained from Bunaji cow breed shows significant ($p < 0.05$) difference between the raw and processed samples. However, significant ($p < 0.05$) decrease of iodine value was observed from the fresh and processed samples in Sokoto-Gudali. This indicates that processing method significantly decreased iodine value in Sokoto-Gudali samples. Result obtained from samples of Holstein-Friesian indicates that processing had no significant ($p < 0.05$) effect on iodine value except when fried with onion where the iodine value significantly ($p < 0.05$) increased.

Table 4.3: Effect of Processing Method on Protein Content of Milk Fat from Different Cow Breeds in Zaria

Processed Milk Fats	COW BREEDS		
	Holstein-Friesian (%)	**Bunaji (%)**	**Sokoto-Gudali (%)**
Raw	$3.41\pm0.14^{a,1}$	$3.57\pm0.16^{a,1}$	$1.76\pm0.36^{b,1}$
Fried	$1.67\pm0.09^{a,2}$	$1.73\pm0.03^{a,2}$	$1.52\pm0.09^{a,2}$
Fried +onion	$3.49\pm0.01^{a,1}$	$3.50\pm0.01^{a,1}$	$1.69\pm0.01^{b,1}$

Values are expressed as mean ± standard deviations of three determinations. Means with different alphabet across the rows and numbers down the columns are significantly different ($p<0.05$).

Table 4.4: Effect of Processing Method on Physical Properties of Milk Fat from Different Cow Breeds in Zaria

Physical Property/ Processing Method	COW BREEDS		
	Holstein-Friesian	**Bunaji**	**Sokoto-Gudali**
Colour			
Raw	White	Golden yellow	Golden yellow
Fried	Pale yellow	Golden yellow	Golden yellow
Fried + Onion	Pale yellow	Golden yellow	Golden yellow
Viscosity (cp)			
Raw	$4.33\pm0.12^{a,2}$	$5.07\pm0.06^{b,3}$	$4.53\pm0.06^{a,2}$
Fried	$3.50\pm0.02^{b,1}$	$2.47\pm0.05^{a,1}$	$3.67\pm0.05^{c,1}$
Fried + Onion	$5.50\pm0.01^{b,3}$	$3.46\pm0.06^{a,2}$	$6.53\pm0.06^{c,3}$
pH			
Raw	$4.67\pm0.12^{c,3}$	$3.64\pm0.01^{a,1,2}$	$4.06\pm0.06^{b,2}$
Fried	$4.37\pm0.06^{c,2}$	$3.52\pm0.10^{a,1}$	$4.05\pm0.12^{b,2}$
Fried + Onion	$3.60\pm0.01^{a,1}$	$3.42\pm0.02^{b,2}$	$3.83\pm0.06^{c,1}$

Values are expressed as mean ± standard deviations of three determinations. Means with different alphabet across the rows and numbers down the columns are significantly different ($p<0.05$) within each physical properties.

Table 4.5: Effect of Processing Method on Chemical Properties of Milk Fat from Different Cow Breeds in Zaria

Chemical Property /Processing Method	COW BREEDS		
	Holstein-Friesian	**Bunaji**	**Sokoto-Gudali**
Acid value (mgKOH/g fat)			
Raw	$4.07\pm0.19^{a,1}$	$9.35\pm0.18^{c,1}$	$4.73\pm0.17^{b,1}$
Fried	$4.40\pm0.18^{a,1,2}$	$10.12\pm0.33^{c,2}$	$6.05\pm0.19^{b,2}$
Fried + onion	$4.73\pm0.17^{a,2}$	$10.23\pm0.38^{b,2}$	$10.45\pm0.18^{c,3}$
Saponification Value (mgKOH /g fat)			
Raw	$243.90\pm1.52^{c,1}$	$220.52\pm0.74^{a,1}$	$232.87\pm1.32^{b,1}$
Fried	$294.17\pm0.76^{c,2}$	$252.52\pm0.76^{a,2}$	$280.06\pm0.76^{b,3}$
Fried + onion	$305.64\pm1.32^{c,3}$	$289.76\pm0.68^{b,3}$	$275.86\pm0.78^{a,2}$
Peroxide value (mEq/kg)			
Raw	$0.10\pm0.01^{a,1}$	$0.10\pm 0.01^{a,1}$	$0.09\pm0.01^{a,1}$
Fried	$0.13\pm0.01^{b,2}$	$0.12\pm0.01^{a,2}$	$0.10\pm0.01^{a,1}$
Fried + onion	$0.14\pm0.01^{c,3}$	$0.13\pm0.02^{b,3}$	$0.11\pm0.01^{a,1}$

Values are expressed as mean ± standard deviations of three determinations. Means with different alphabet across the rows and numbers down the columns are significantly different ($p<0.05$) within each physical property.

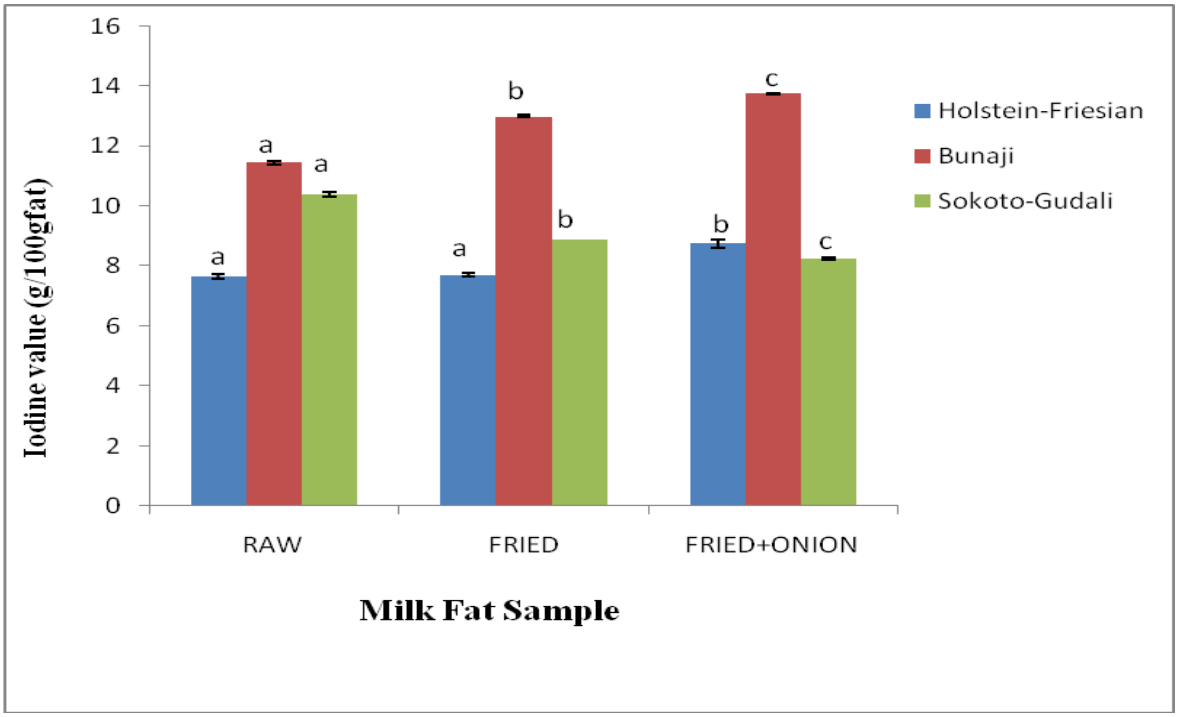

Figure 4.2: Effect of Processing on the Iodine Value of Milk Fat from Different Cow Breeds in Zaria

Values are expressed as mean ± standard deviations of three determinations. Means with different alphabet within the same cow breed are significantly different ($p<0.05$).

4.7 Fatty Acid Profile of Milk Fat from Milk of Different Cow Breeds in Zaria

The fatty acid composition of the fresh milk fat from milk of different cow breeds in Zaria is summarized in Table 4.6. The predominant fatty acids in BNJ milk fat are palmitic (16:0) (57.21%), capric (10:0) (6.96%), lauric (12:0) (6.65%), and caproic (6:0) (6.02%). Saturated fatty acids accounted for 91.62% of the total fatty acids and monounsaturated fatty acids 7.33%. The proportion of intermediate chain-length saturated fatty acids (C10-C14) was 17.34%. There were no α-linolenic, (18:3 ω-3) and γ-linolenic, (18:3 ω-6) polyunsaturated fatty acids, but a small proportion (1.05%) of linoleic (18:2 ω-6) was found.

The predominant fatty acids in SGL milk fat are palmitic (16:0) (83.90%), linoleic, (18:2 ω-6) (8.61%), pentadecanoic (15:0) (7.12%) and oleic (18:1, ω-9) (0.37%). Saturated fatty acids accounted for 91.01% of the total fatty acids and monounsaturated fatty acids 0.37%.

The predominant fatty acids in HLF milk fat are palmitic (16:0) (67.47%), tridecylic (13:0) (15.26%), lauric (12:0) (3.78%) and caproic (6:0) (3.78%). Saturated fatty acids accounted for 96.23% of the total fatty acids and monounsaturated fatty acids 3.78%. The proportion of intermediate chain-length saturated fatty acids (C10-C14) was 21.69%.

4.8 Effect of Processing Method on Fatty Acid Profile of Milk Fat from Milk of Different Cow Breeds in Zaria

The fatty acid composition of the processed milk fat samples from the three cow breeds is summarized in Table 4.7. The predominant fatty acids in the fried sample from BNJ are myristic (14:0) (30.09%), stearic (18:0) (25.12%), lauric (12:0) (20.39%), palmitic (16:0) (8.39%) and capric (10:0) (8.39%). Saturated fatty acids accounted for 92.38% while monounsaturated fatty acids accounted for 3.19% of the total fatty acids. The proportion of intermediate chain-length saturated fatty acids (C10-C14) was 58.87%. The proportions of unsaturated fatty acids were 1.53% for petroselinic (18:1 ω-12), 4.97% for oleic (18:1 ω-9) and

1.12% for elaidic (t18:1 ω-9). While in fried with onion sample, the predominant are palmitic (16:0) (39.65%), oleic (18:1 ω-9) (51.08%) and tricosylic (C23:0) (9.27%). This indicates that saturated fatty acids accounted for 48.92% while monounsaturated fatty acids accounted for 51.08% of the total fatty acids. The proportion of long chain-length saturated fatty acids (C16-C23) was 48.92%. The proportion of unsaturated fatty acid oleic (18:1 ω-9) was 51.08%.

The predominant fatty acids in the fried sample from SGL milk fat are myristic (14:0) (32.22%), palmitic (16:0) (32.22%), oleic (18:1 ω-9) (25.15%) and myristoleic (14:1, ω-5) (10.41%). From this fried sample of milk fat from SGL, saturated fatty acids accounted for 64.44% while monounsaturated fatty acids accounted for 3.19% of the total fatty acids. The result from the fried sample of SGL milk fat also showed that the proportion of polyunsaturated fatty acids; oleic acid 18:1(n-9) and myristoleic acid (14:1n-5) were 35.56%. While in the fried with onion sample, the fatty acids present are lauric (12:0) (58.81%) and capric (10:0) (41.19%), these accounted for 100% of the total fatty acids.

The predominant fatty acids in the fried sample from HLF milk fat are elaidic (t18:1 n-9) (55.78%), palmitic (16:0) (27.13%) and tridecylic (C13:0) (6.14%). Saturated fatty acids accounted for 38.69% while monounsaturated fatty acids accounted for 61.31% of the total fatty acids. The proportion of intermediate chain-length saturated fatty acids (C10-C14) was 7.20%. The proportions of polyunsaturated fatty acids were 59.79% for t18:1(n-9) and 1.52% for (18:1 n-9). While in the fried with onion sample, the predominant fatty acids were vaccenic t18:1(n-7) (46.24%), oleic, (18:1 ω-9) (29.29%) and petroselinic (18:1 n-12) (24.47%), the monounsaturated fatty acids accounted for 100% of the fatty acids present in the sample.

Table 4.6: Fatty Acid Profile of Milk Fat from Milk of Different Cow Breeds in Zaria

	PROPORTION OF FATTY ACID (%)		
FATTY ACIDS	**HLF**	**BNJ**	**SGL**
Saturated Fatty Acids			
Caproic Acid (6:0)	0.3	2.58	ND
Caprylic Acid (8:0)	ND	1.59	ND
Palmitic Acid (16:0)	5.35	24.51	2.24
Capric Acid (10:0)	0.21	2.98	ND
Lauric Acid (12:0)	0.3	2.85	ND
Tridecylic Acid (13:0)	1.21	0.52	ND
Arachidic Acid (20:0)	ND	0.24	ND
Myristic Acid (14:0)	ND	1.08	ND
Pentadecylic Acid (15:0)	0.26	1.96	0.19
Margaric Acid (17:0)	ND	0.64	ND
Unsaturated Fatty Acids			
Linoleic Acid (18:2 ω-6)	ND	0.45	0.23
Myristoleic Acid (14:1 ω-5)	ND	1.31	ND
Oleic Acid (18:1 ω-9)	0.3	0.11	0.01
Palmitoleic Acid (16:1 ω-7)	ND	1.72	ND
Total Saturated Fatty Acids	96.22	91.56	91.01
Total Unsaturated Fatty Acids	3.78	8.44	8.99

HLF= Holstein-Friesian, BNJ= Bunaji, SGL= Sokoto-Gudali and ND = Not Detected

Table 4.7: Effect of Processing Method on the Fatty Acid Profile of Milk Fat from Milk of Different Cow Breeds in Zaria

	PROPORTION OF FATTY ACID (%)								
COW BREEDS	**HLF**			**BNJ**			**SGL**		
FATTY ACIDS	**FRESH**	**FRIED**	**FRIED+ONION**	**FRESH**	**FRIED**	**FRIED+ONION**	**FRESH**	**FRIED**	**FRIED+ONION**
Saturated Fatty Acids									
Capronic acid	0.3	0.3	ND	2.58	ND	ND	ND	ND	ND
Caprylic acid	ND	ND	ND	1.59	ND	ND	ND	ND	ND
Palmitic acid	5.35	3.51	ND	24.51	3.51	8.26	2.24	2.6	ND
Capric acid	0.21	0.21	ND	2.98	3.51	ND	ND	ND	1.38
Lauric acid	0.3	0.21	ND	2.85	8.53	ND	ND	ND	1.97
Tridecylic acid	1.21	1.21	ND	0.52	ND	ND	ND	ND	ND
Arachidic acid	ND	ND	ND	0.24	ND	ND	ND	ND	ND
Myristic acid	ND	ND	ND	1.08	12.59	ND	ND	ND	ND
Pentadecylic acid	0.26	0.26	ND	1.96	ND	ND	0.19	ND	ND
Margaric acid	ND	ND	ND	0.64	ND	ND	ND	ND	ND
Elaidic acid	ND	11.79	ND	ND	0.47	ND	ND	ND	ND
Petroselinic acid	ND	ND	2.44	ND	0.64	ND	ND	ND	ND
Stearic acid	ND	ND	ND	ND	10.51	ND	ND	ND	ND
Tricosylic acid	ND	ND	ND	ND	ND	1.93	ND	ND	ND
Vaccenic acid	ND	ND	4.61	ND	ND	ND	ND	ND	ND
Unsaturated Fatty Acids									
Linoleic acid	ND	ND	ND	0.45	ND	ND	0.23	ND	ND
Myristoleic acid	ND	ND	ND	1.31	ND	ND	ND	0.84	ND
Oleic acid	0.3	0.3	2.92	0.11	2.08	10.64	0.01	2.03	ND
Palmitoleic acid	ND	ND	ND	1.72	ND	ND	ND	ND	ND
Total Saturated Fatty Acids	96.22	98.48	70.71	91.56	95.03	48.92	91.01	47.53	100.00
Total Unsaturated Fatty Acid	3.78	1.52	29.29	8.44	4.97	51.08	8.99	52.47	0.00

HLF= Holstein-Friesian, BNJ= Bunaji, SGL= Sokoto-Gudali and ND = Not Detected

CHAPTER FIVE

5.0 DISCUSSION

To my knowledge, this is the first work that investigates the pattern of milk fat consumption in Zaria Local Government Area of Kaduna State, Nigeria. The study shows that milk fat consumption is recognized in most households in Zaria. The present study is in agreement with that conducted among Yoruba ethnic group at Ibadan by Jabbar and Domenico (1993), which shows a high consumption of milk fat among milk products. This high consumption of the milk fat in the study area may be due to its availability and affordability. Results for the compositions of milk differed from previously published studies, as the present results generally showed higher levels of fat, protein and dry matter for both local and exotic breeds. Fat content was higher in the local breeds when compared to the exotic breeds, and SGL had significantly ($p< 0.05$) higher fat content than BNJ. White *et al.* (2001) reported that Jersey and HLF cow managed under similar conditions produced on average 4.1% and 3.3% fat respectively. The present findings show lower values of milk fat when compared to the report on variation in fat content among milk of cow breeds by Hurley (1997); Belewu (2006); Jack (2014). A report from Ethiopia indicates that the variation in the fat content may be ascribed as in the genetics and physiological status of the cow breeds (Frank, 1988). It may also be attributed to different herd management by the owners (Zeleke, 2007). According to Belewu (2006), a variation in fat content among breeds of cow is an inherited character which implies that breeds with high milk production, content small quantity of milk fat. Work on cow milk from different breeds by Adesina (2012), indicated that when managed under similar conditions, 3.60%, 4.45% and 3.40% of milk were the fat content for BNJ, Red Bororo and Muturu, respectively. Moreover, values for the fat content in this study were higher than (4.70±0.06%) from Bunaji cow breed as reported earlier from Abeokuta, Nigeria by Oladapo *et al.* (2015).

The results showed that dry matter content was higher in the local breeds compared to the exotic breed, with SGL having significantly ($p < 0.05$) higher content than BNJ. The results were slightly lower than the range of 12.4% and 12.5% total solid for the milk of grazing BNJ cows (Oladapo *et al.,* 2015). Ojedapo *et al.* (2014), however, reported lower value of 10.48% while higher fats values of 13.7% and 15% were reported by Olafadehan and Adewumi (2010), Olorunisomo *et al.* (2014) in BNJ cow's milk in the total solids. Differences in utilization of nutrients and management of the cows could influence the variation of percent total solids in milk across study (Matthewman, 1993).

There is significant ($p < 0.05$) difference in the protein content among SGL and the other two cow breeds with BNJ and HLF having similar value and processing without onion significantly ($p < 0.05$) reduced the protein content in both HLF and BNJ. White *et al.* (2001) reported the concentrations of protein content to be 2.87% for HLF and 3.62% for Jersey. Adesina (2012) from Ado-Ekiti also reported protein content of 3.68%, 3.54% and 3.66% for BNJ, Red Bororo and Muturu cow breeds, respectively, compared to the findings of the present study. Similarly, Kelsey *et al.* (2003) reported the protein content to be similar as White *et al.* (2001), with HLF producing 3.03% and Jersey producing 3.46% of their milk as protein. Jack, (2014) reported concentrations of protein to be 3.84% for Jersey and 3.24% for HLF respectively. When compare to the present study, these four studies show similar concentrations of protein in the milk of the cow breeds used. One potential reason for the discrepancies in reported levels of milk fat and protein between previous findings and this study contributes in the management of the animals, environment, stage of lactation (O'mahony, 1988) and it could also be attributed to breed differences as well as metabolic activities of bacteria present in the milk. However, these values were within the range of 3.43% to 4.10% as earlier reported (Tayo *et al.*, 2005; Oladapo *et al.,* 2015), but higher than 3.16% and 3.18% obtained from Igo-Iwoye by Alemede and Sadiq (2008), Olafadehan and Adewumi (2010) for extensively managed BNJ cow breed.

Moreover, values for the fat content in this study were higher than that of the protein content which agrees with earlier reports (Olorunisomo *et al.,* 2014; Oladapo *et al.,* 2015). Although the levels of protein in all the samples from the three cow breeds were lower than 12% calorific value of protein recommended for food to be a good source of protein (FNB, 2002), when combine with other food source it could be of high biological value.

Physical and chemical properties are the most important properties that determine the present state or condition of fat or oil. Viscosity means resistance to flow. The viscosity of fats and oils decreased slightly with an increase in unsaturation, therefore viscosity is increased slightly by hydrogenation. Oils and fats containing greater proportion of fatty acids of relatively low molecular weight are slightly less viscous than ones of an equivalent degree of unsaturation, but containing higher proportion of high molecular weight acids (Lawson, 1995). The viscosity value of fat from local breeds was significantly ($p< 0.05$) higher compared to the exotic breed and processing generally decreased ($p< 0.05$) this value. Earlier works on whole milk and skim milk by Wong *et al*. (1988); Walstra *et al.* (1984) display viscosities of 2.0–2.1cp and 1.5–1.8cp at 20°C respectively, which are lower when compared with the present findings.

The acid value of fat from BNJ was significantly ($p < 0.05$) higher compared to both HLF and SGL, and processing significantly ($p < 0.05$) increased the acid value. This is an indication that the fat from BNJ might be more unstable at room temperature (Falade *et al.,* 2008). Abdel Moneim *et al.* (2013) from Sudan reported a much lower values of 0.56 ± 0.0, 1.42 ± 0.07, 0.64 ± 0.17 and 1.94±0.17(mgKOH/kg) for Medani, Rofaa, Elobied and Laboratory made milk fat samples, respectively. The value of acid of milk fat could be increased as a result of contamination during its preparation or handling Abdel Moneim *et al.* (2013). Another work from Ogbomosho, Oyo state, Nigeria by Bello *et al.* (2013) reported a much higher range of acid values of 15.71mgKOH/g to 26.93mgKOH/g from onion's oil. The general significant ($p < 0.05$) increase of the acid value in all the fried with onion samples from the present study

might be that leaching of some acids from the onion had taken place while frying. The levels of acid values obtained in this study were observed to be much higher compared to the result (0.374mgKOH/g) obtained by Dhurvey *et al.* (2012) while working on cow ghee from India. Reports from Khartoum, Sudan and Ghana show a similar acid values as found in the present study (Mahboba and Zubeir, 2007; Enb *et al.,* 2009; Akabanda *et al.,* 2010). Moreover, much lower acid values of 1.44mgKOH/g and 0.28mgKOH/g were also reported from Pakistan and Ethiopia by Imran *et al.* (2008); Asaminew and Eyassu, (2011), respectively.

The saponification value has been useful screening test for quality control and characterizing types of fats and oils (Abdel Moneim *et al.,* 2013). From the present study, the saponification value of fat from HLF was significantly ($p < 0.05$) higher compare to the local breeds and processing significantly ($p < 0.05$) increased SV. Similar value of 224.5g/100g was reported from India by (Dhurvey *et al.,* 2012). Bello *et al.* (2013) from Ogbomosho, Oyo state, Nigeria reported a higher SV of 316.96mgKOH/g, 255.26mgKOH/g and 350.62 mgKOH/g for oil from onion bulb, top-bottom and outer scale wastes, respectively. But results obtained in the present study show a higher value than that of sunflower oil 192.3mg/KOH/g and that of soybeans 192.3Gkoh/kg (Falade *et al.,* 2008). The values obtained were higher than that reported from Sudan by Abdel Moneim *et al.* (2013); 165.50, 172.23, 171.11 and 163.81 mgKOH/g for Medani, Rofaa, Elobied and laboratory made milk fat samples, respectively. The values obtained in this study showed that the fats are suitable for soap production as they will not require high amount of potassium hydroxide to saponify one gram of the fat.

Peroxide value below 10meq/kg is characteristic of fresh fat or oil while values between 20 and 40meq/kg could result to rancid taste (Eka *et al.,* 2009). Peroxide value obtained in the present study from all the three breeds was similar and processing significantly ($p < 0.05$) increased PV. The PV obtained in the present study is an indication that processing can be used for preservation of milk fat without deterioration. Higher value of 8.1g/100gfat was reported from

India by Dhurvey *et al.* (2012). However, a lower value of was reported from Abeokuta, Nigeria by Manoj *et al.* (2010).

Iodine value is the measure of unsaturation of fat. In the present study, local breeds had higher iodine value compared to the exotic breed with BNJ having significantly ($p< 0.05$) higher value than SGL and processing significantly ($p< 0.05$) increases the IV in both HLF and BNJ cow breeds, hence increasing the degree of unsaturation in the samples from these cow breeds. Values obtained in the present study are higher compared to that 3.46 g/100gfat reported earlier from Indian by Dhurvey *et al.* (2012). The IV obtained in the present study is very much lower compared to 143.35±0.83, 142.08±0.05 and 189.52±0.04 (g/100g oil) for Onion bulb, Top-bottom and Outer scale, respectively as reported by Bello *et al.* (2013).

Fatty acids mostly originate from the hydrolysis of the milk fat. The lipase responsible for their production probably originates from the milk itself (Stadhouders *et al.,* 1983). The fatty acids analyzed showed the distribution of fatty acids to follow a similar pattern while still being specific for each product. Seven fatty acids were identified in the fresh milk fat of HLF, six of which were saturated and one was unsaturated. Fourteen fatty acids were identified in the fresh milk fat of BNJ, ten of which were saturated while four were unsaturated and four fatty acids were identified in the fresh milk fat of SGL, two of which were saturated. The most predominant saturated fatty acid in all the three samples was palmitic acid (16:0) and BNJ had the highest quantity, followed by lauric acid, (12:0). On the other hand, the most predominant unsaturated fatty acid was oleic acid followed by linoleic, (18:2 ω-6) acid which is present only in samples from local cow breeds and processing leads to its disappearance. The current study shows similar concentrations of fatty acids (SFA or USFA) in HLF, BNJ and SGL milk fat when compared to those values reported by previous researchers. White *et al.* (2001) reported that saturated fatty acids comprised 64.41% of HLF milk and 67.19% of Jerseys' milk. The CLA concentration in the milk fat of HLF was also similar to those values reported by previous

research works. Jack (2004) reported that Jersey and HLF managed under similar conditions produced a CLA content of 0.43% and 0.56% of the total fatty acids respectively. Kelsey *et al.* (2003) reported a similar result, with HLF producing 0.44% of the total fatty acids as CLA. The major source of CLA in milk relates to the conversion of vaccenic acid, (t18:1 ω-7) into CLA through the enzymatic activity of the Δ^9- desaturase (Palladino *et al.*, 2010). In the present study, it was only HLF breed that produced vaccenic acid (t18:1 ω-7) in the processed sample with onion.

The essential fatty acid, linoleic acid, (18:2 ω-6), was found in measurable quantities in the local breeds only and processing leads to disappearance of this acid which might be due to its conversion to shorter chain fatty acids that could easily evaporate probably as a result of their volatilization during preparation, in particular the step which involves frying the milk fat (Wayua *et al.*, 2007). Jack (2014) reported similar levels of linoleic acid, (18:2 ω-6) for HLF and Jerseys cow breeds managed under similar conditions with higher concentrations of palmitic acid (C16:0). Oleic acid was found to be present in samples from the three cow breeds with HLF having the highest quantity and processing appreciably increased the quantity of this fatty acid. Result obtained in the present study is similar to previously reported data. Herb *et al.* (1962) reported that the predominant unsaturated fatty acid from cow milk fat was oleic acid which comprises 30% of the total milk fat.

CHAPTER SIX

6.0 SUMMARY, CONCLUSION AND RECOMMENDATIONS

6.1 Summary

Cross sectional survey of 398 randomly selected households within Zaria, revealed that 87.7% of the households consumed milk fats, 35.5% consume it at least once a week, 15.19% consume monthly while 49.28% consumes it sometimes when available.

Milk sample from SGL produced significantly ($p < 0.05$) higher milk fat and dry matter content and significantly ($p < 0.05$) lower protein content when compared to the other two cow breeds and frying without onion significantly ($p < 0.05$) decreased the protein content of milk fat of both BNJ and HLF while frying with onion had no significant ($p < 0.05$) effect on the protein content of all the samples.

Physicochemical analysis revealed that viscosity at $60^{o}C$ was significantly ($p < 0.05$) higher in BNJ when compared with both SGL and HLF and processing significantly ($p < 0.05$) reduced the level of viscosity in samples from all the breeds. Acid value of milk fat from BNJ is significantly ($p < 0.05$) higher than those from SGL and HLF and processing significantly ($p < 0.05$) increased the acidic value in all the three cow breeds. However, HLF had significantly ($p < 0.05$) higher saponification value and processing also significantly ($p < 0.05$) increased SV except in SGL where processing without onion had significantly ($p < 0.05$) higher value than the others. BNJ milk fat had significantly ($p < 0.05$) higher iodine value and processing significantly ($p < 0.05$) increased the iodine value, however, processing significantly ($p < 0.05$) decreased this value in HLF.

HLF produced more saturated fatty acids than BNJ and SGL (96.23%, 91.56% and 91.01%, respectively). Linoleic acid was produced in similar quantity by both BNJ and SGL breeds, but BNJ produced slightly higher quantity (0.45%) than SGL (0.23%). HLF produced higher levels of oleic acid in its milk fat (0.3%) when compared to BNJ and SGL (0.11 and 0.01%)

respectively. Appreciable amount of (1.31% and 1.72%) for myristoleic and palmitoleic acids were only observed in BNJ. From the analysis of concentrations of both selected fatty acids as well as groups of major fatty acids, there was evidence that the fatty acids profile of milk fat differs with respect to breed of cow and that processing affects the composition of fatty acids present. Breeds and processing methods used in this study significantly ($p < 0.05$) contribute to the differences in the physicochemical properties and nutrient profile.

6.2 Conclusion

From the present study, it can be concluded that milk fat "*Manshanu*" is widely consumed (88% HH) in Zaria. The local breeds had significantly ($p < 0.05$) higher fat and dry matter contents than the exotic breed under the same grazing condition, with Sokoto-Gudali having highest. Processing methods used in this study significantly ($p < 0.05$) reduced protein and increased content of unsaturated fatty acids and most physicochemical properties from the three cow breeds used in this study.

6.3 Recommendations

i. Consumption of processed milk fat from our local breeds (BNJ and SGL) should be encouraged because of their content of essential fatty acids.

ii. Extension work on the local processing method using onion is recommended since it has a potential of retaining more nutrients than without using the onion.

iii. Work on preservation using the local processing is recommended so as to providing alternative system for food security by preserving an otherwise normally very perishable product, thus relieving existing nutritional shortages among some Nigerians.

iv. More extensive studies are needed on the *trans*-fat content of milk fat from the local cow breeds after processing.

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APPENDIX 1

CONSUMPTION PATTERN OF LOCAL BUTTER (MANSHANU) IN ZARIA LOCAL GOVERNMENT OF KADUNA STATE

SURVEY QUESTIONANAIRE

(This questionnaire is to be administered to female household's caregiver)

Date_____ Questionnaire No., _____

Ward _____ Community _____

Household Address _____

(Be as descriptive as possible)

Interviewer's name _____ Signature_____

SECTION A: CHARACTERISTICS OF RESPONDENTS

1. Age___ (years) 2. Ethnic group _____ 3. Household size _____ 4. Marital status: Married [ ] Single [ ] Divorce [ ]

SECTION B: MANSHANU COSUMPTION

5. Do you know Manshanu? (Show a sample) Yes [ ] No [ ]

6. If yes for (5) above, have you ever eaten Manshanu? Yes [ ] No [ ]

7. If yes for (6) above then how frequently do you eat it? At least (a) once per week [ ] (b) twice or more per week [ ] (c) once per month [ ] (d) twice or more per month [ ] (e) sometimes [ ]

8. Do you eat it raw? Yes [ ] No [ ]

9. Do you eat the Manshanu alone or in combination with other foods?

Alone Yes [ ] No [ ]

In combination with other foods Yes [ ] No [ ] If yes list the foods

i. _____ii. _____ iii. _____ iv. _____

10. In your family, are you the only one that eat Manshanu or all members of your family? (Specify) _____

11. What do you dislike about Manshanu? _____

SECTION C: MANSHANU PREPARATION

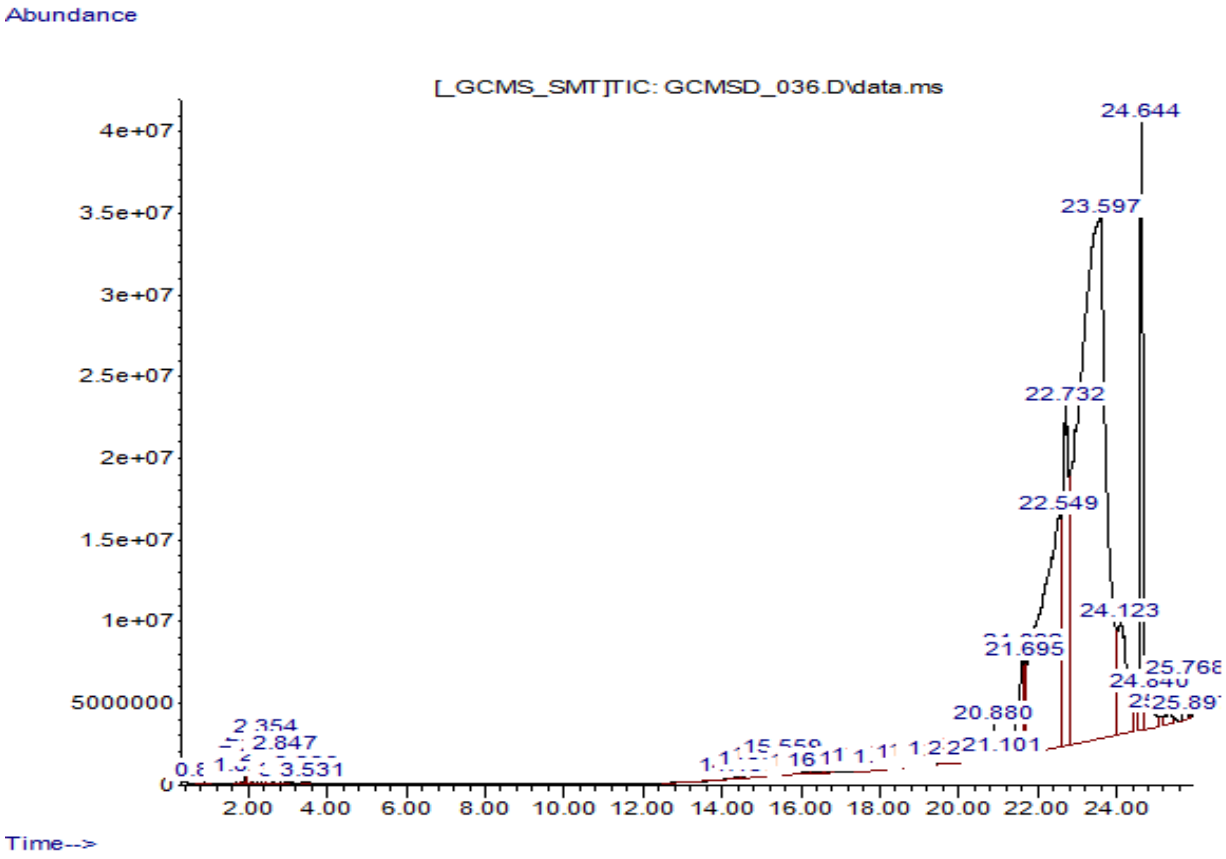
12. Do you prepare your Manshanu or you buy them? Prepare [ ] buy [ ]

13 If you prepare Manshanu, list the ingredients, quantity, duration and method you use to prepare Manshanu

INGREDIENT	QUANTITY	DURATION	METHOD/PROCEDURE

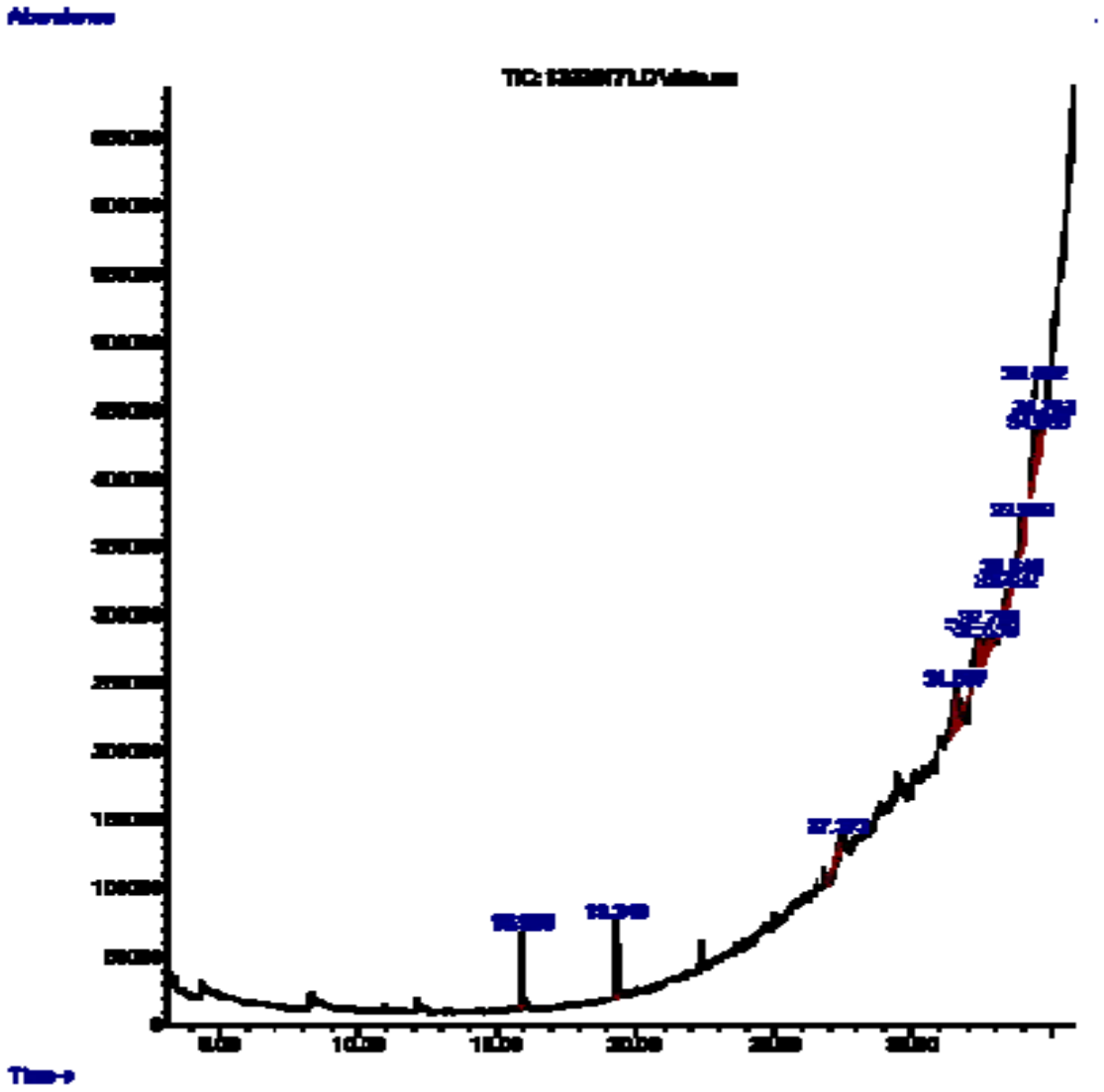
14. Apart from eating, what other things do you use Manshanu for? List the important ones i._____ ii. _____ iii. _____ iv. _____

APPENDIX 2



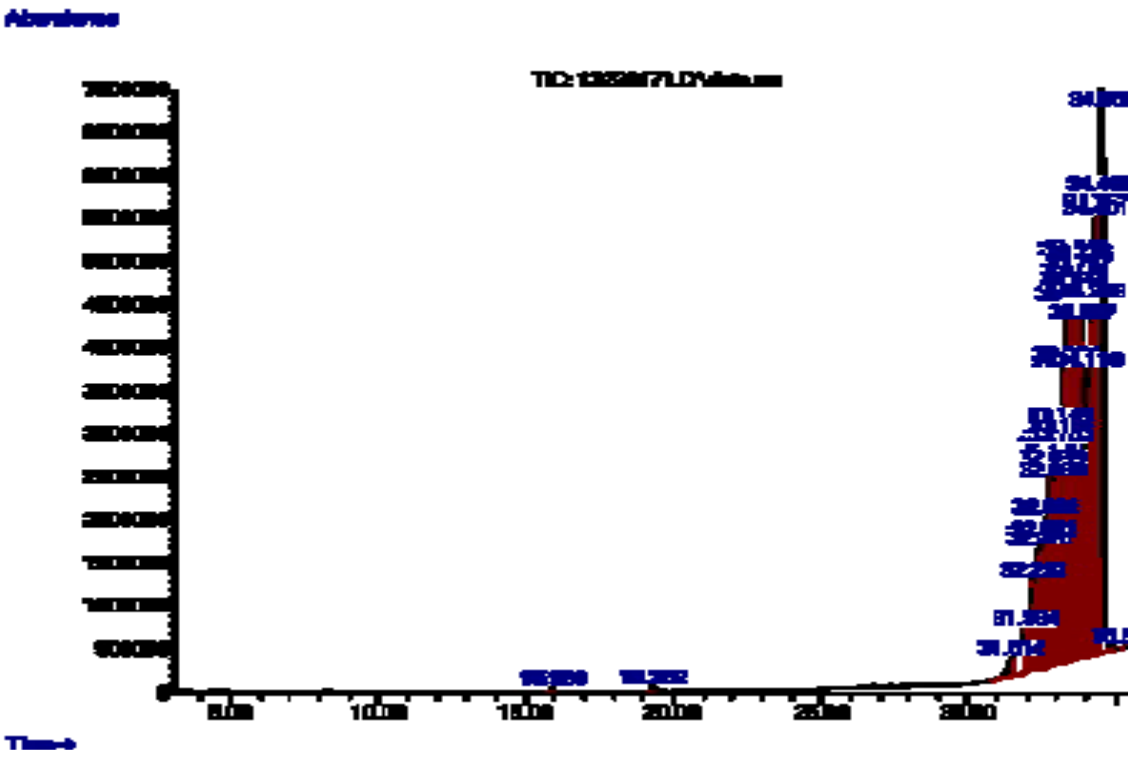
GCMS Spectrum for Fresh Milk Fat Sample from Sokoto-Gudali

APPENDIX 3



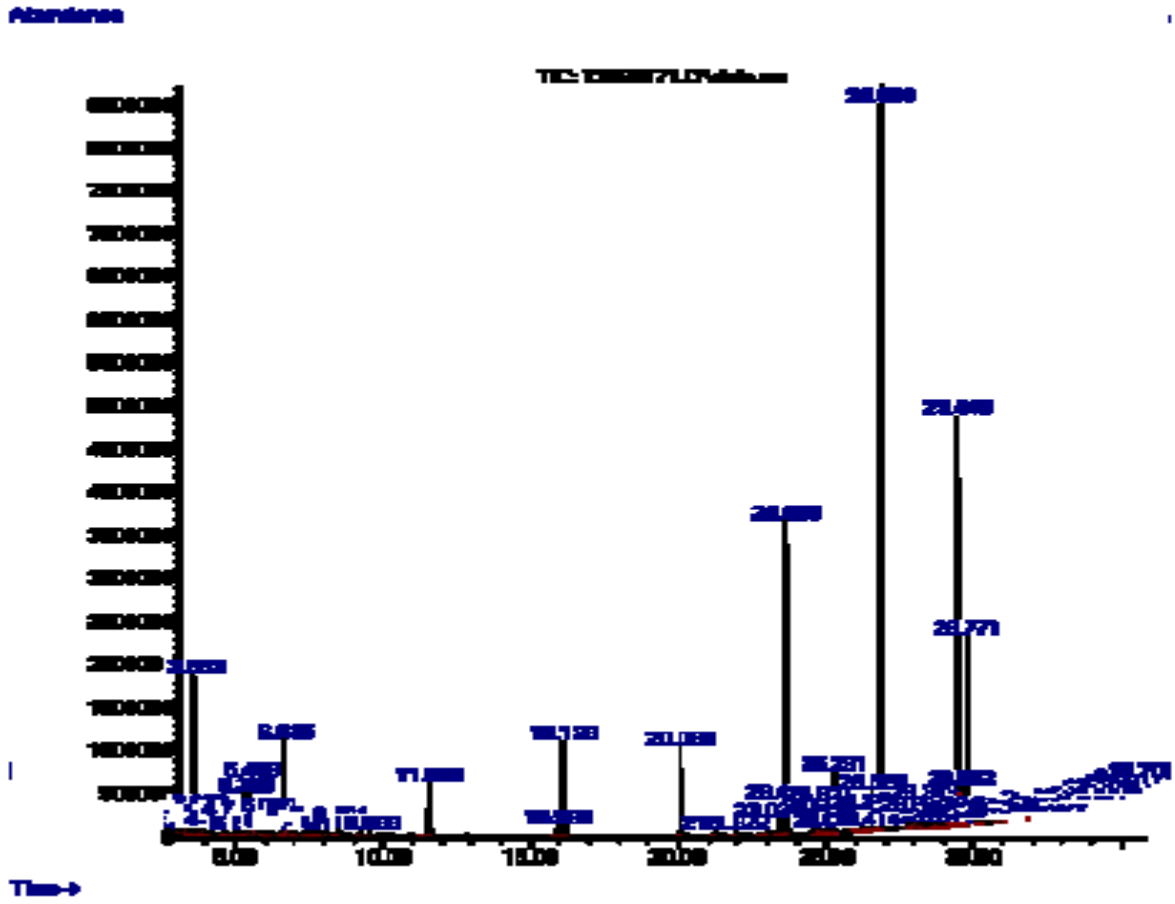
GCMS Spectrum for Fried Milk Fat Sample from Sokoto-Gudali

APPENDIX 4



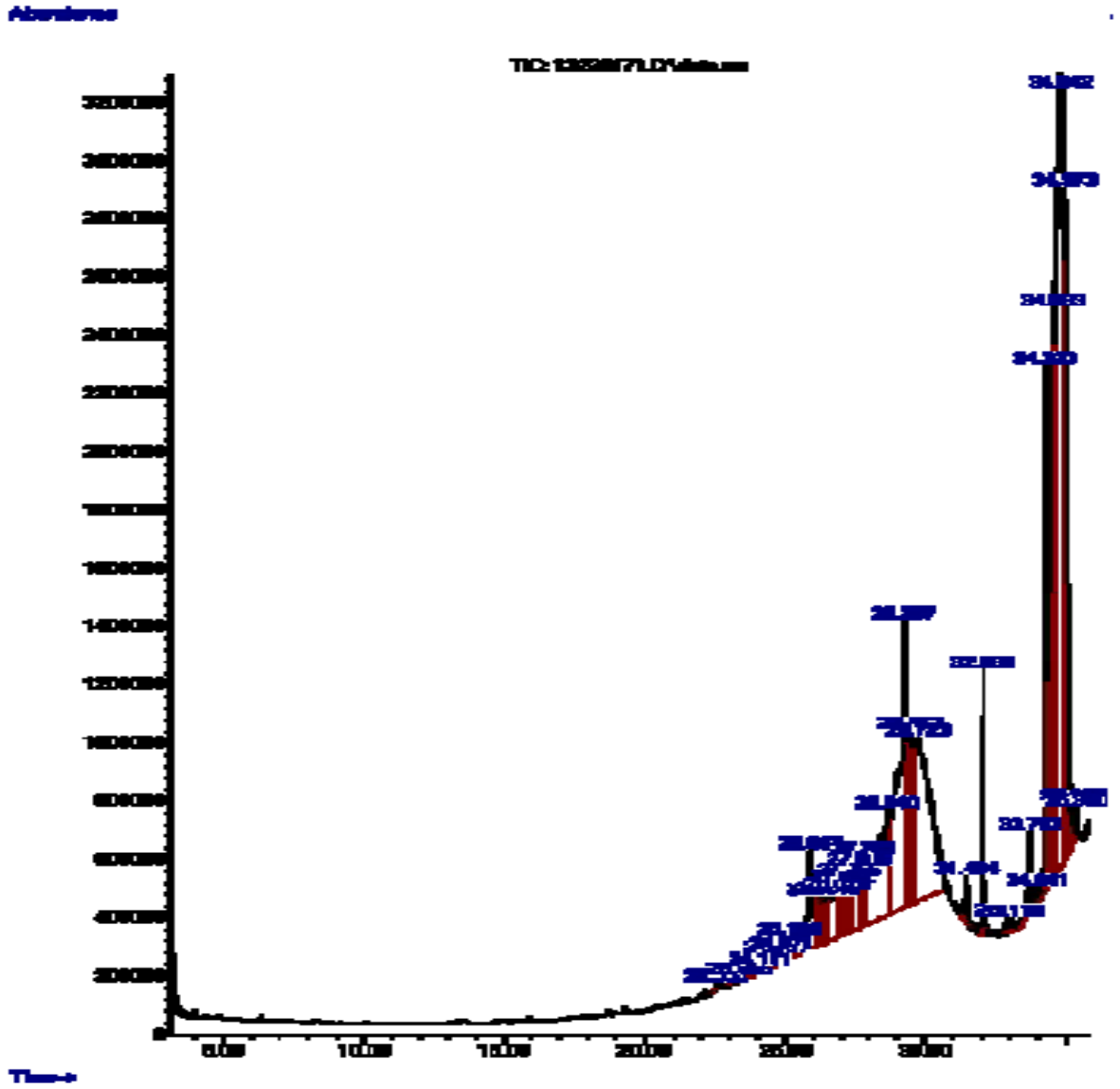
GCMS Spectrum for Fried with Onion Milk Fat Sample from Sokoto-Gudali

APPENDIX 5



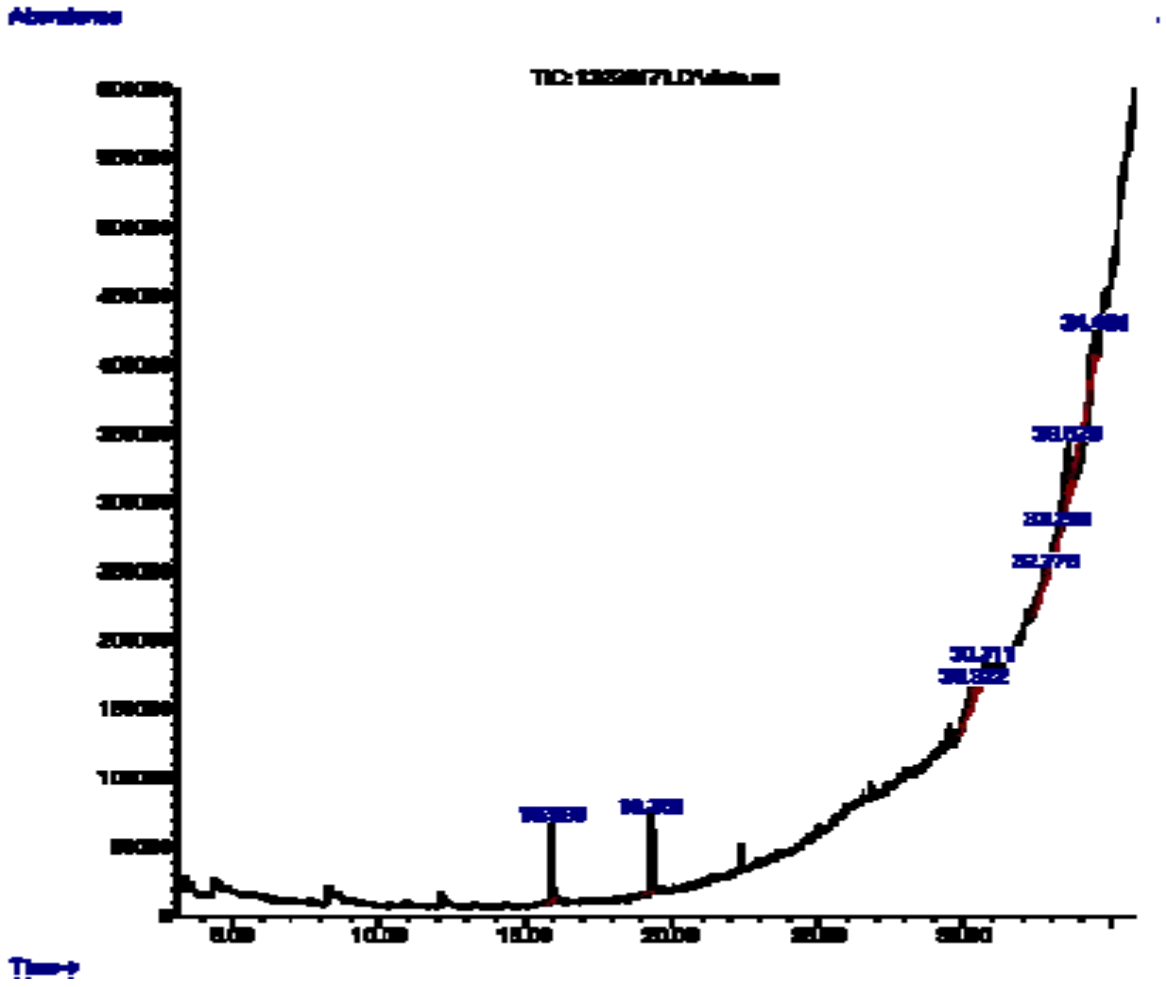
GCMS Spectrum for Fresh Milk Fat Sample from Bunaji

APPENDIX 6



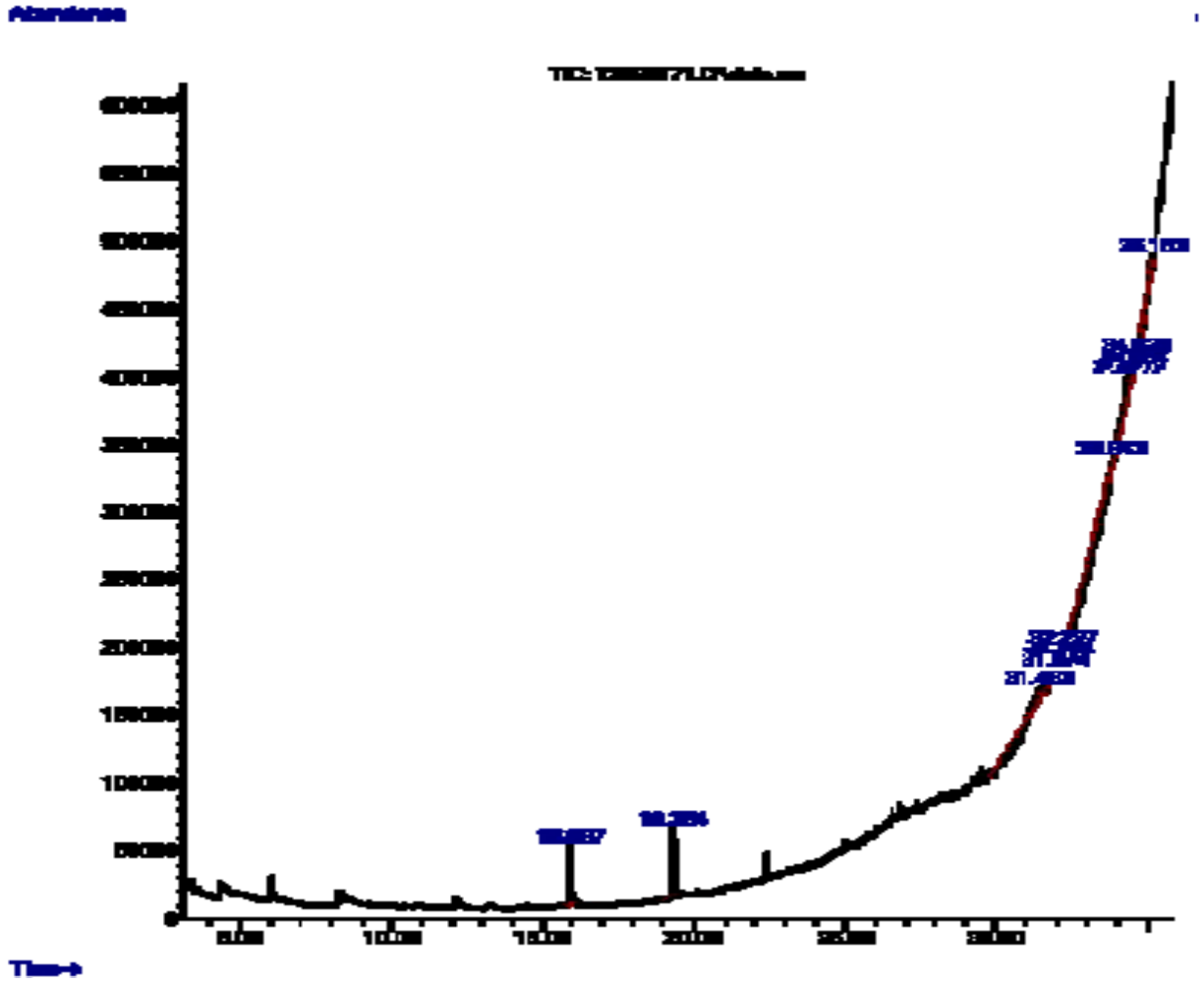
GCMS Spectrum for Fried Milk Fat Sample from Bunaji

APPENDIX 7



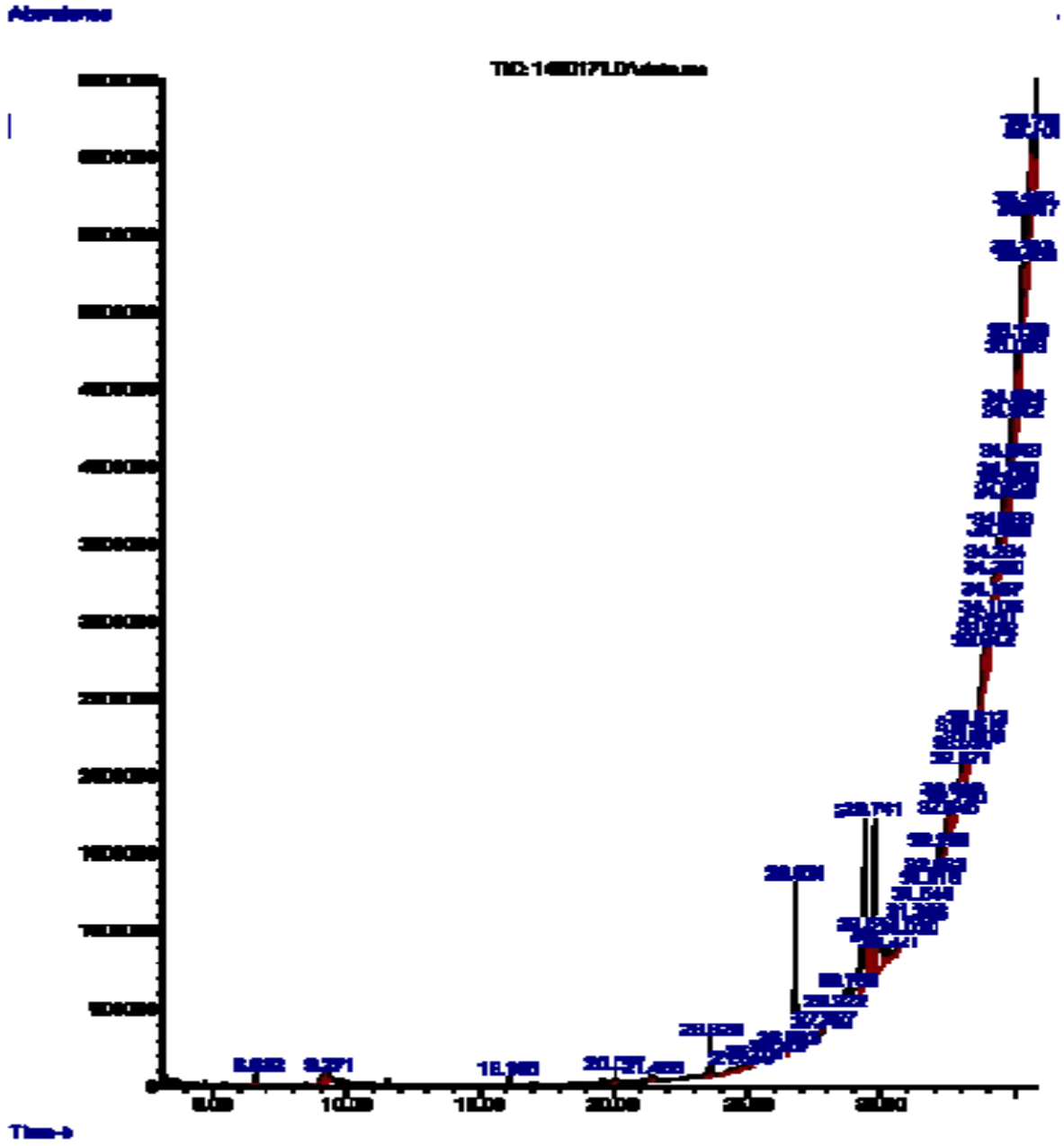
GCMS Spectrum for Fried with Onion Milk Fat Sample from Bunaji

APPENDIX 8



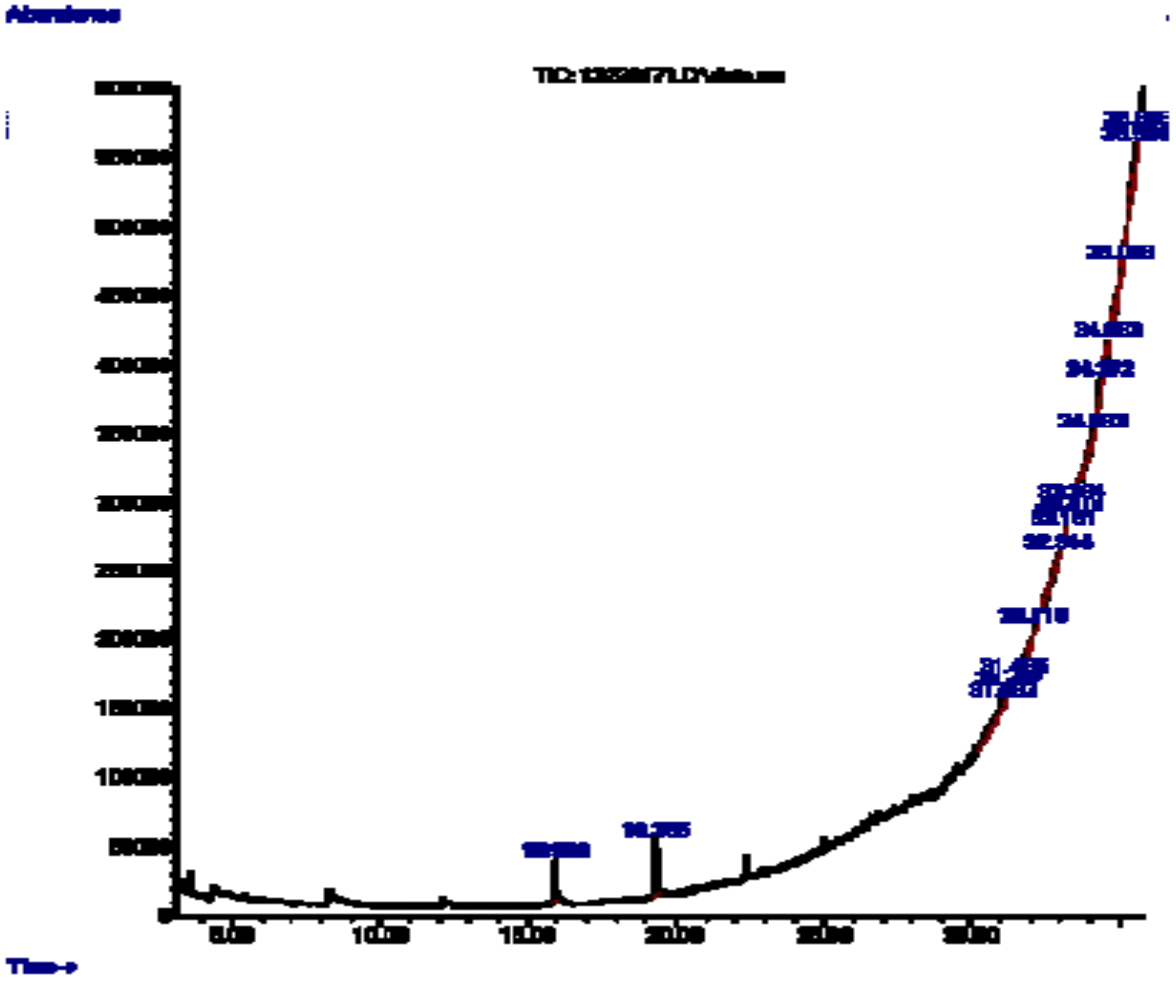
GCMS Spectrum for Fresh Milk Fat Sample from Holstein-Friesian

APPENDIX 9



GCMS Spectrum for Fried Milk Fat Sample from Holstein-Friesian

APPENDIX 10



GCMS Spectrum for Fried with Onion Milk Fat Sample from Holstein-Friesian