Chapter One
Introduction

1.1. Introduction:

The real beginning of cheeses-making is unrecorded in history. However, it must have been occurred within few centuries after the domestication of the cows and other mammals about 8000 B.C. (Clarence *et al*. 2004 and Shukla, 2010).

There are great varieties of cheese some are perishable and must be consumed within few days after production while other can be stored for years. Cheeses can be made from the milk of cow's, sheep, goats and camels (Herrington, 2000) it can also be made from cream milk , skim milk, whey or a mixture of two of these and each type of milk imparts the characteristics quality of cheese made from it and the resulting cheese will diver in body, texture and flavor (Andrew, 2010).

The objective of cheese making is to obtain the optimum cheese composition with respect to moisture, acidity, pH, fat, protein and minerals. Cheese making can be described as the process of removing water, lactose and some minerals from milk to produce a concentrated milk fat and protein. The essential ingredients of cheese are milk, coagulating enzyme (rennet), bacterial cultures and salt. Rennet causes the milk proteins to aggregate and ultimately transform fluid milk to a semi-firm gel. When this gel is cut into small pieces (curds), whey will then begins to separate from the curds (Price, 1974).

According to Ramkant (2006) cheese is a product that made from the curd obtained from milk by coagulating the casein with the help of rennet or similar enzymes in the presence of lactic acid microorganism and then ripened by holding it for some times at suitable temperature and humidity. Law (1999) and

Fox *et al*., (2004) defined cheese as the fresh or ripened product obtained after coagulation and whey separation of milk, cream or partly skimmed milk, buttermilk or a mixture of these products. Natural cheese should be stored at suitable temperature to ensure good quality because a high temperature leads to evaporation of moisture and growth of unwanted bacteria and other faults , also a very low temperature leads to moulds growth (due to high humidity) and may result in a damage of the texture (Ramakant ,2006). Warsama *et al*., (2006) reported that Sudanese white soft cheese is locally known in Sudan as (Gibna Bayda) or Gibbna which is the most famous name and it is usually stored in containers filled with whey (Kur, 1992).

Vegetable**s cheese is a cheese containing 100% natural ingredients. The product can be produced with low fat cheese as a base or can be a product with entirely vegetables ingredients, vegetables oils, sometimes vegetables proteins and carbohydrates may be added, it is also** can be produced with any desired amount of saturated or unsaturated fats, other non of milk proteins and carbohydrates that should be part of the standard eating pattern of today's consumer. Vegetables cheese contains less cholesterol and contains low micro-biological values than cheese from animal origin (Kosikowski and Mistry, 1997).

Cassava **(***Manihot esculenta)* is originated from the American tropics but it is now grown through the tropical world. It is an important food crops in many south and Central American countries and part of West Africa (William, 1989). It was first grown for food by the American Indians and then introduced to Africa in the sixteenth centaury from Brazil it was first introduced to east Africa and Congo in the eighteenth century (Michael, 1991). The cassava plant is a staple crops and it's very essential for food security in the humid and sub humid tropics of Africa (Thottapilly, 1992).

There are many varieties of cassava; some are maturing from 5 month onward while others may take up to 15 months or more (Irvine ,1979), and it is classified as sweet or bitter cassava (Ravindran, 1991). Before it is utilized cassava tuber is almost peeled. The peel represents about 10-20 % of the tuber. The layer represents about 0.5-2.0 % of the total tuber weight and the edible flesh make up 80-90 % of the tuber. The tuber flesh is composed of about 61 % water , 35 % carbohydrates , 1-2 % protein 0.3 % fat 1-2 % Fiber and 2 % minerals. Especially cassava roots are very rich in minerals and contain significant amounts of calcium, phosphorus and vitamin C (Olsen, 1999).

For the making of cassava flour, the fresh roots are peeled, washed and cut into large slabs. The slabs are then allowed to dry under the sun and stored. When the flour is needed the dry slabs can be milled to produce grayish white flour which can be used for producing of many types of food (John and Sons 1978).

1.2. Research problems:

The cow's milk in South Sudan is very poor in both quantity and quality, even the quality of the cheese made from it is limited and poor. In order to provide the consumer with valuable sources of nutrients cassava powder can be used to upgrade the nutritional value of the white cheese and to improve the quality of the cheese due to its high contents of calcium, phosphorus and vitamin C.

1.3. Research objectives:

1- To study the physicochemical composition and sensory characteristics of the Sudanese white soft cheese as affected by the different levels of cassava powder and storage period.

2- To evaluate the microbiological changes of the Sudanese white soft cheese manufactured from different levels of cassava powder during the storage period.

3- To determine the effects of different levels of cassava on the yield of the Sudanese white soft cheese.

4- To evaluate the effect of different levels of cassava on some minerals and vitamin C contents of the Sudanese white soft cheese.

Chapter Two

Literature Review

2.1. The milk:

Milk is a white secretion of the mammary glands and it is sterile when secreted from the udder (Tolle, 1980). Milk also can be defined as the normal secretion of the mammary gland of mammals and cannot be a colostrums or a colostrums milk like (Clarence *et al*, 2004). It's secreted by the female mammals for the purpose of rearing their offspring (O'Connor, 1993).

As given by Henderson (1971) it is an excellent food especially for the growing children. Milk is regarded as the only food that provides a well-balanced essential nutrients in a form of which is palatable, digestible and sanitary (Kordylas, 1991). Fresh whole milk is a valuable source of vitamin A, Riboflavin, Thiamin and other B vitamins and it is important source of vitamin C in dry areas as mentioned by (Payne, 1990). It also contains components that are essential to humans such as proteins, carbohydrates, fat, vitamin D, calcium and phosphorus and it also provides energy (Pauline and Karin 2006).

Milk is also a source of energy and natural essential nutrients. Beside these nutrients, milk contains compounds such as conjugated linoleic acid and butyric acid. Milk has been an important part of the human diets as far back as 6000 years (Payne, 1990). Hence milk represents also a source of nutrition for nomads who live exclusively on it for months (Kon, 1972).

Normal milk consist of about 13 to 14 percent total solids, 86 to 87 percent water and 3 to 6 percent butter fat. Good milk has rich flavor and very little

odor. It must not appear dirty, discolored or watered down and must be free from diseases (Thomas, 1980).

2.2. Chemical composition of milk:

Milk is a complex mixture of water, fats, protein, lactose, minerals, vitamins and enzymes. Milk composition differs between species, breeds and individuals (Payne, 1990).

2.3. Fermented dairy products:

Fermented dairy products have a long and culturally diverse history. The origins of fermented dairy products can be traced far back to Persian times (8000 BC) in the Middle East when, as it is believed, the art of cheese making was introduced (Rose *et al*., 2002).

Campbell-Platt (1987) defined the fermented foods as those foods which have been subjected to the action of microorganisms or enzymes so that desirable biochemical changes cause significant modification to the food. Fermented milk products originated from near East and subsequently gained popularity in Europe. Fermentation process, which occurs in the fermented milk, results in conversion of lactose to lactic acid. This acid has preservative effect on milk. The low pH of fermented milk inhibits the growth of undesirable bacteria and pathogenic organisms. The starter cultures used for fermentation of milk convert part of lactose to lactic acid , carbon dioxide , acetic acid , dactyl , acetaldehyde and several other materials (Walstra *et al* ., 1999).

2.3.1. Yoghurt:

Yogurt is a fermented product prepared from milk of high solids content. Some quantity of water is evaporated from milk or skimmed powder is added. This milk of high SNF content is subjected to fermentation by the symbiotic growth of two types of bacteria (Lactobacillus *bulgaricus* and *Streptococcus*

thermophilus). The resultant product is quite thicker and is used for direct consumption with or without sweetening by addition of sugar (Patricia, 1984).

Yoghurt is obtained from pasteurized milk, cream or a mixture of two or more of these products (Mahindru, 2009).To make yoghurt, milk should first be heated to 85°C or higher. A high pasteurization temperature (above 72°C) gives a better consistency (thickness) to the final product. After the milk has been soured, the resulting yoghurt can be used to make more fresh yoghurt by adding it to fresh milk (Pauline and Karin, 2006; Walstra e*t al.*, 1999 and Fox *et al*., 1993). Current trend for using prebiotics and probiotics cultures in the manufacturing of fermented milks and yogurt products is in response to consumer expectations for functional or wellness foods. The beneficial effects documented in numerous studies and reviews include; prevention of cancer, reduction in diarrhea associated with travel, antibiotics therapy and rotavirus, improvement of gastrointestinal health, enhancement of immunity of the host, amelioration of lactose intolerance symptoms, protection from infections caused by food-borne microorganisms and vaccine adjuvant effects (Chandan, 2008).

2.3.2. Butter:

Butter is the concentrated form of milk fat. According to prevention of food adulteration rules (PFA) Butter should contain not less than 80 % of fat, a maximum of 1.5 % curd content and all fat soluble vitamins such as vitamin A,D,E and K and its made by churning cream, sour cream or sour milk (Mahindru , 2009). Pauline and Karin (2006) added that butter has a limited shelf life and can become mouldy or rancid. An unpleasant cheese-like flavor may develop due to the deterioration of its protein (Josef, 1989).

2.4. Cream:

Cream is a fat rich portion separated from whole milk; it contains all milk constituents in varying portions. According to prevention of food adulteration rule (PFA) cream should contain 20-25 % milk fat (Pauline and Karin, 2006).

2.5. Ghee:

Ghee is produced by removing the last water remnants from butter by heating the butter and letting the water evaporated, or by melting butter and draining the water which separates from the fat (Pauline and Karin, 2006). Ghee is an important milk product which has been extensively used throughout the country for dietary. Ghee is the clarified butter fat prepared either from cream or butter, it is the richest sources of milk fat among all the dairy products (Ibraheem and Sheeba, 2004). As stated by Mahindru (2009) ghee has a rich and good flavor.

2.6. Ice cream:

It is a frozen dairy product made from suitable blending and processing of cream and other milk products together with sugar and flavor with or without stabilizer or color and with the incorporation of air during the freezing process (Ibraheem and Sheeba, 2004).

2.7. Milk powder:

Milk powder is a dried product prepared by evaporating water content of milk by heat or other suitable means to produce a solid product containing 5 % or less moisture. Whole milk or skim milk may be used for drying and the products obtained are called whole milk and skim powder respectively (Arvind, 2010).

Table 1: The major differences in the chemical composition of milk of the different animal species:

Milk sources	Fat %	Solid %	Protein%	Lactose %	Minerals%	Calcium%	Vitamin A IU	Sugar %	Energy (Cal/100g)
Friesian cow	3.5	-	3.3	4.6	-	0.1	-	4.94	62
Guernesy cow	4.7	-	3.2	4.7	-	0.1	-	4.94	75
Temperate cow	3.5	8.5	3.3	4.6	0.75	0.12	150	4.94	-
Zebu cow	5.0	8.5	3.2	4.6	0.75	0.13	-	4.94	-
Buffalo	7.5	9.0	3.8	4.9	0.75	0.19	100	4.44	-
Sheep	7.5	11.5	6.0	4.4	1.00	0.2	500	4.17	105
Goat	4.0	8.7	3.4	4.2	0.13	0.85	8	4.64	71
Camel	4.2	9.0	3.8	5.0	-	-	-	5.59	70
Lam	3.2	-	3.9	5.3	-	-	-		65
Mare	1.6	-	2.2	6.0	-	0.1		5.87	47
Donkey	1.5	-	2.1	6.2	-	0.1			46
Polar	33.1	14.5	13.8	0.3	-	-	-		-
Human	4.0	9.0	1.3	6.8	0.03	-	10	6.37	73

Note: Missing figures means information was unavailable

Source : (Kon,1972 ; Warner,1978 ;Wilson, 1984;Pauline and Karin,2006;Godobole,2007 and Clarence *et al*.,2004)

2.8. Whey:

Years ago whey was treated as an insignificant by-product of cheese-making used mainly in animal feed; whey contains high quality protein, lactose, minerals (calcium, phosphorus, magnesium, zinc, vitamins and traces elements of milk fat). Whey protein is of high biological value compared to the most other proteins; and it has a high content of sulpher-containing amino acids (McBean, 2003).

Whey may help to protect against cancer and cardiovascular disease; and enhance the performance of physically active individuals (I D F, 1997 and Dairy Export Council, 2003). In addition to that several whey proteins, including lactoferrin and its peptide derivative, lactoferricin, have been shown to inhibit the activity of a diverse range of microorganisms and some harmful food borne pathogens (Josef, 1989).

2.9. Cheese:

Basically cheese is a concentrated form of milk obtained by coagulating the casein. This entraps most of milk fat and some of the milk sugar (Lactose), water and serum protein (albumin and globulins) most of the water and water-soluble constituents are expelled as whey (The International Commission of Microbiological Specifications for foods, 1980).

Chemical and Engineering News (2002) defines cheese as a concentrated dairy food from milk. According to Scott (1986) cheese can be defined as the solid food made from the milk of cows, goat, sheep and other mammals and has a longer shelf life than the milk from which it is made.

Law (1999) and Fox (2000) defined cheese as the fresh or ripened product obtained after coagulation and whey separation of milk, cream or partly skimmed milk, buttermilk or a mixture of these products. James (2013) gave a simple definition for cheese as a fresh or ripened product obtained after

coagulation and whey separation of milk, cream or partly skimmed milk, butter milk or a mixture of these products.

Other definition for cheese was given by Shukla (2010) and Ramakant (2006) who stated that cheese is a food made from milk usually the milk of cows, buffalo, goats or sheep by coagulation.

As mentioned by Josef (1989) cheese is a milk curd a substance obtained from the coagulation of milk by rennet and acid-separated from the whey and processed remolded into a solid mass. It contains concentrated milk solids, water rennet, bacterial cultures, salt and some times calcium chloride.

Cheese can also be defined as a solid curd with some or all of the whey drained off. It is either used fresh or after maturation. It is widely used all over the world. The curd is made by the action of rennet, lactic acid bacteria or organic acids such as lemon juice or vinegar (Payne, 1990). Due to differences between regions and the specific technology used in the processing of milk, numerous cheeses were developed, such as Cheddar, Gouda and Mozzarella. These products have one thing in common, namely that the LAB is responsible for the acidification (Law and Tamime, 2010).

2.9.1. The origin of cheese:

There is no conclusive evidence indicating where cheese-making originated from , either in Europe , central Asia or the middle East , but the practice had spread within Europe prior to Roman time and it had become a sophisticated enterprise by the time the Roman Empire came into the being (Arvind ,2010).

The proposed date for the origin of cheese-making range from around 8000 BCE (when sheep were first domesticated) to 300 BCE. The people of Greece used cheese from 1000 to 450 BC and the Romans from 775-750 BC (Clarence *et al.* 2004).

The first cheese may have been made by the people in the Middle East or by nomadic Turkic tribes in central Asia. Since the animal skin and inflated internal organs have since ancient time provided storage vessels for foods staff , its probably that the process of cheese-making has been discovered accidently by storing milk in a containers made from the stomach of an animal , resulting in a milk being turn to curd and whey by the rennet from the stomach. There is a widely told legend about the discovery of cheese by an Arab trader who used this method for the storing of milk. The legend has much individual variation in addition to that Archaeological evidence of cheese making has been found in Egyptian tomb, dating to about 2000 BCE. The earliest cheese were likely to have been quite sour and salty (Shukla, 2010).

There are more than thousand varieties of cheese all over the word and there is no absolute method of classification. The classification is based on several proprieties and characteristics, such as fat content, source of milk, method of coagulation and whether ripened or unripened. A simple and commonly used method is according to moisture contents (UNFEM, 1996 and Rhea, 2009).

Cheese making provide an incentive for improving dairying as well as creating new jobs , it also improves the local diet and raises the standard of living gradually, through a better understanding of hygiene scientific technologies and community sprit. In the third world the local's cheese plant often serves as a center for community activities (Josef, 1989). Cheese making is a complicated process, involving many process steps and several biochemical transformations. All of these variables affect yield, composition, quality of the cheese and its by-products (whey) and often in different ways. Consequently, optimization of cheese making is an intricate affair. Even the control of the composition of the end product, a rather straight forward activity for most dairy products, is not easy to achieve in cheese making. Moreover, the way of processing may

strongly affect production costs , additives needed, labor, equipment, product loss, etc (Walstra *et al*., 2006).

Cheese is one of the most varied and suitable food in the world, the variations of characters has made cheese so appreciated as a food for hundreds, even thousands of years (Richard, 1978). Approximately one third of the world's milk production is used in cheese manufacturing (Farkye, 2004). Egypt has the highest cheese production of the African countries and accounts for about 67 % of the African cheese production.

2.9.2. Sudanese white soft cheese:

The cheese making in Sudan is concentrated mainly in the white soft cheese (Abdel Razig, 1996). Khateeb (1997) and Warsama *et al.*, (2006) reported that a Sudanese white soft cheese is locally known in Sudan as (Gibna Bayda) or Gibbna which is the local name for the white cheese and its the most famous name , and it is usually stored in containers filled with whey (Kur, 1992). Sudanese white soft cheese traditionally is processed in different areas of Sudan. The cheese may be consumed fresh or after maturation in salt brine or salted whey (Abdalla and Abdel Razig, 1997).

Sudanese white cheese is widely consumed by people of all socioeconomic classes; most of it is made in houses and some private farms. The cheese is delivered to the market immediately after processing. White cheese is the only type of cheese available to the public at large quantities on the markets of Sudan, the method of its production was introduced from Egypt or through Egypt from Mediterranean countries such as Syria or Greece (Dirar, 1993 and Ali, 1987).

Sudanese white cheese falls into the family of soft and semi-soft pickled cheese of east European countries, the East Mediterranean region and North Africa (Abdalla, 1992). Cheeses plays an important role in the Sudanese diets and

many people eat a certain amount of cheese with at least twice per week in one of their meals, most of the cheese is consumed either directly or with bread.

Ahamed (1987) reported that the existing method of making Sudanese white cheese has been first introduced by a Greek family (Catherina and Panaioti Maestro) who settled in Al-Dueuim in 1908 and they later in 1987 suggested that white cheese was introduced into Sudan from Egypt during colonial time (1898-1956) and then a Sudanese merchant later took up the manufacturing task adding their own flavor to the product. El Owni and Hamid (2008) added that Cheese making in Sudan is the major preservation method for surplus milk in rural areas especially during rainy season when plenty of milk is available.

2.9.3. Chemical composition of the Sudanese white soft cheese:

During the storage of the Sudanese white cheese at room temperature changes in the chemical composition can occur. In Sudan different investigators reported variable results concerning the chemical composition of the Sudanese white cheese. Ali (1987) reported that the mean values of moisture in the white cheese were 3.33 %, protein 13.8 %, fat 14.0 %, salt 7.9 %, pH values 4.0 and titratable acidity was 1.0 %. Many other investigators reported that the white cheese may contain the following chemical composition: fat 13-37%, protein 12.82-22.6, moisture 38.2- 64.21%, ash 1.33 - 4.82, titratable acidity 1.33 -1.60 % and pH 4.4 - 6.3 % depending on the ingredients used in the manufacturing of cheese (Kwak *et al*., 2002 ; Shirashoji *et al*., 2006; Kapoor *et al*., 2007 and Pinto *et al*., 2007).

Ibrahim (2003) examined thirty samples of the Sudanese white cheese and he showed that their average content of moisture , salt , pH value and titratable acidities were 44.2 , 4.3 , 4.6 and 2.3% respectively. While Ahmed and Khalifa (1989) found that moisture content of fresh cow's milk cheese was 56.1 % and their protein content was 21.3 %. Alla Gabo (1986) examined 24 sambles of Sudanese white cheese from Khartoum market and explained that the mean

values of their moisture content, protein, fat, salt and pH values were 61.2, 22.2, 12.8, 4.2 and 4.0 % respectively.

Nuser (2001) studied the chemical composition of fresh white cheese and found that the fat content were 25.13 % , protein 23.26 % , total soilds 48.47 % , ash 3.5 % and titratable acidity was 0.66 % . The average chemical composition of Sudanese white cheese as stated by Sulieman *et al.*, (2005) were 50.31% total solids, 49.49% moisture, 20.12 % protein, 22.27 % fat, 4.76 % salt, 5.57% ash, 1.64 % lactose, 4.85 % pH, 1.85 titratable acidity, 1.70 (0.1 N ml NaOH/100 g cheese) volatile fatty acids, 10.02 mg/100 g and acetaldehyde, 30.89 mg/100 g.

Waleed *et al*.(2013) collected five samples of white cheese produced at different small scale-level in El-Dueim city and he showed that protein content of the cheese ranged from 14.17 ± 0.058% to 15.73 ± 0.150%, with an average value of 14.57%, fat content ranged between 18.92 ± 0.012% to 22.27 ± 0.087%, with an average value of 20.84% and ash content of cheese samples ranged from 3.77 ± 0.012% to 5.60 ± 0.087%, with an average of 4.45%. The fatty acids content varied and the most abundant were palmitic (C_{16}: 0), stearic (C_{18}: 0) and myristic (C_{14}: 0) acids), which ranged between 14.56 to 39.41, 0.04 to 19.31 and 0.59 to 1.30 g/100 g respectively. Most of the amino acids were found in cheese samples. They also added that the macro and micro elements of the Sudanese white cheese were as follows : P ranged from 91.12 ± 0.136 to 108.00 ± 2.309 (Mg) , Ca range from 398 ± 16.166 to 521 (Mg) , K range from 49.33 ± 1.853 to 79.00 ± 4.041(Mg) , Na range from 189 ±1 0.790 to 315 ± 8.083 (Mg) , Zn (range from 5.39 ± 0.341 to 7.90 ± 0.445(Mg) and Fe range from 0.34 ± 0.029 to 0.77 ± 0.035 (Mg).

Abdalla and Hassan (2013) studies some minerals contents of the white cheese stored in plastics containers at the first day of its manufacturing and they reported that it contains about 19.50 ppm (parts per million) of calcium , 11.130 ppm sodium and 0.0480l ppm lead.

2.9.4. Packaging of the Sudanese white soft cheese:

Sudanese white cheese is delivered to the market immediately after processing, under inadequate conditions, poor handling technique, inappropriate packaging materials and lack of adequate storage facilities (Khalid, 1991). Ibrahim (2003) and Osman (2005) stated that the essential dairy products including cheese must be safe, acceptable and meet consumer's satisfaction. As a result, cheese production must be protected from pathogenic and spoilage microorganisms, as well as from decaying both on the sites of production and consumption (Scott,

1986). For these reasons proper packaging method is very important for chemical, physical and microbial quality of white cheese (Khalid, 1991).

Packaging of cheese is one of the most important steps in the long journey from the producer to the consumers, since most of the cheese plants are far away from the consumption (Abdalla *et al*., 2013 and Ahmed, 1985). Several factors are involved in selecting a package for cheese these are type of cheese , resistance to mechanical damage , presence of specific flora , whole sale or retail packaging , permeability to water vapor , presence of oxygen and carbon dioxide or both , ammonia , light , labeling facilities , migration of flavor from package material to products and the system for storage (Walstra *et al* .,1999).

The packaging process undertakes several basic roles such as preventing microbial and chemical quality deterioration and enhancing the handling and marketing for packaged products. Now days, food packaging not only targets convenience and protection properties but also presents many other applications such as extending the shelf life and storage of food products (Han, 2005) , and general protection of the product from mechanical damage and poor environmental conditions during handling and distribution (Ahmed,1985). Frazier and Westhoff (1978) reported that packaging of cheese is to minimize loss of moisture and penetration of oxygen which can help in mould growth. Ahamed (1985) stated that Sudanese white cheese was packed in tins proved to hazardous because they cause reaction with milk acids and that result in corrosion. Banwart (1981) indicated that plastic containers are sterile, but they become contaminated if not handled in an acceptable way. Plastic containers are now widely used for backing of cheese in Sudan.

Vacuum packaging is found to be effective in improving the quality and shelf life of cheese (Papaioannou *et al*., 2007 and Favati *et al*., 2007). Abdalla and Mohamed (2009) investigated the effect of vacuum packaging on chemical composition and sensory properties of white soft cheese and found that sensory

properties are gradually improved. However, vacuum packaging is currently not feasible in rural areas of Sudan where the majority of cheese is produced. In a laboratory trial Nour El Diam and El Zubeir (2007) reported that glass packaging was more acceptable compared to plastic packaging (70% and 30%, respectively).

2.9.5. Cheese ripening:

The cheese ripening (maturation) is a complex process involving a range of microbiological and biochemical reactions. Microorganisms are present in cheese throughout ripening and contribute to the maturation process either directly through their metabolic activity or indirectly through the release of enzymes into the cheese matrix through autolysis (Fox *et al.*, 2004). During the ripening of cheese, three major biochemical events - glycolysis, lipolysis, and proteolysis - occur; each of them is involved in flavor formation. The ripening process varies depending upon the type of cheese. During ripening, chemical and enzymatic reactions occur that result in the development of flavor and changes to the body, texture and physical properties of the cheese. Temperature during ripening, pH of the cheese, manufacturing protocol, addition of specific enzymes and microorganisms affect these changes. Kim *et al*., (1992) reported that fat and protein tended to increase due to rapid decrease of moisture content during ripening.

Cheeses ripened into distinct varieties partly because they are made physically different by the technology in the cheese plant and partly because they are made with different microbial cultures. After the cheese curd has been formed, salted, pressed and placed in the maturation area, its microflora will start working transforming the bland product of the fermentation stage into a cheese whose flavor, texture and appearance are largely dependent on the microorganisms present within the curd mass or on its surface. Some of these microorganisms will have been added deliberately as the starter culture, as a ripening blue or

white mould culture, or as a surface smear of bacteria and yeasts. Others, mainly non-starter lactic acid bacteria (NSLAB) (lactobacilli and pediococci) gain access to the cheese from the milk or from the factory environment or added as adjunct culture and contribute to ripening from within the cheese through their biomass (enzymes and substrates) and their metabolism (Law and Tamime , 2010).

2.9.6. Cheese storage:

Natural cheese should be stored at low temperatures to ensure good quality. A high temperature leads to evaporation of moisture, growth of unwanted moulds and taint producing bacteria and other faults'. A very low temperature also leads to moulds growth because of the relatively high humidity usually associated with it and may result in a damaged texture. The suitable storage temperature for cheese may be 5-10^{o}C (Ramakant, 2006).

2.9.7. Nutritional value of cheese:

Cheese is a good source of a nutritional value, especially because of its calcium and protein content which are identified as an important factors driving consumers desire to consume cheese (Dairy Management, 2000; Berry, 2002 and Harding, 1999). Protein in cheese is containing all of the essential amino acids in the amounts proportional to the body's needs and it's digestible because some of the proteins are broken down during the ripening (Kosikowski and Mistry, 1997). Many reduce fat varieties of cheeses are available for individuals monitoring or reducing fat in their diet, also Individuals can include cheese in a fat reduced diet (McBean, 2002).

Because of their low lactose, most cheeses are well for individuals who have difficulty digesting lactose (lactose mal digesters) (Miller *et al*., 2000). Moreover because cheese is high in calcium, it is inclusion in the diet, which reduces the risk for osteoporosis. In addition, cheese in moderation, is included

in the diet designed to reduce the risk of hypertension, also reduce factors for heart disease (McBean, 2002).

Food value of cheese is well known and cheese is sometimes called as solid milk. A kilogram of cheese has practically twice the food value of equal quantity of meat. As the manufacturing of cheese is based on break down of milk protein, it is easily digestible when taken with reasonable quantity of carbohydrates. It is potential source of milk proteins, calcium, phosphorus and fat soluble vitamins (A, D, E, and K) (Subhasish and Subhash, 2006 and Walstra *et al.*, 1999).

In general cheese supplies a great deal of calcium, protein and phosphorus. A30-gram serving of cheddar cheese contains about 7 grams of protein and 200 milligrams of calcium. Nutritionally, cheese is essentially concentrated milk, it take about 200 grams of milk to provide that much protein and 150 grams to equal the calcium. Some studies claim to show that cheese can help to prevent tooth from decaying (Arvin, 2010).

McBean (2002) reviewed cheeses nutritional contribution to the diet, many reduce fat varieties of cheeses are available for individuals monitoring or reducing fat in their diet, also individuals can include cheese in a fat reduced diet. He also reported that certain cheeses have been demonstrated to reduce the risk of dental caries. He added that cheeses have an anti-carcinogenic effect, so consuming cheese may stimulate the flow of saliva, which has caries reducing properties. In addition to that cheese protein has been demonstrated to neutralize plaque acids, which are produced during the fermentation of sugars and starches by plaque bacteria, and cheese appears to prevent acid demineralization and enhance demineralization of tooth and reduce tooth decay. Because of their low lactose, most cheeses are well for individuals who have difficulty digesting lactose (lactose mal digesters) as stated by (Miller *et al.*, 2000).

2.10. Minerals in milk and dairy products:

Minerals are substance necessary for maintenance of life and good health. Some are essential components of body maintenance such as calcium in bones and iron in hemoglobin. Other helps to regulate the activities of metabolisms. As their availability to needs, minerals are divided into two groups, Macro minerals and Trace (Micro) minerals: Macro minerals are calcium (Ca) – phosphorus – (P) – sodium (Na) – chlorine (Cl) – potassium (K) – magnesium (Mg). Ca and P are the most abundant of the minerals in feed ration and dairy products including cheese (Leaver, 1983 and Chhazllani, 2008).

2.10.1. Calcium:

Mahindru (2009) reported that calcium is an essential element required for the formation and manufacturing of Skelton and teeth, for the contraction of muscles to make limbs move, for contraction of heart for its normal function are cared out by ionized calcium present in the cells. The calcium levels in the cells and plasma are well maintained by the calcium present in the bones, he added that calcium is present in both animal and plant foods. The richest source of calcium among the animal foods is milk and milk products such as butter, skimmed milk and cheese 30, 120 and 790 mg/100g respectively.

2.10.2. Phosphorus:

Phosphorous is another element in the body next in importance after calcium. Otherwise also utilization of calcium is closely linked with that of phosphorous since most of calcium deposited in the body is calcium phosphate in the bone and teeth. Phosphorous is also a component of nucleic acids and phosphorous esters play an important part in the cellular metabolism of other nutrients like carbohydrates, fat etc. As needed for energy formation of foods, its deficiency results in general weakness, bone pain and decrease appetite, the amount of phosphorus in cheese is about 520 mg/100 g (Mahindru, 2009). About 70 percent of the body and their metabolisms are closely interrelated with calcium and phosphorus (Leaver, 1983).

2.10.3. Sodium and potassium (Na/K):

Sodium and potassium both are electrolytes. Bothe of them are important constituents of fluids present outside and within the cell. Their proper concentration is essential to maintain osmotic balance and keep the cells in proper shape. Potassium prevents sodium from raising blood pressure (B.P). Too much excess of potassium also can removes calcium deposits (Mahindru, 2009). According to Chhazllani (2008) potassium **(** K) also served to maintain proper acid levels in the body fluids and pressure in body cells. It is also required some enzymatic reactions in carbohydrate metabolisms and protein synthesis.

Sodium helps to maintain water balance inside and outside the body cells. Its deficiency can cause muscles cramps and edema. Its excess has harmful effects like high blood pressure kidney disease. Sodium deficiency is rare; its excess needs to be guarded (Mahindru, 2009). Sodium (Na) and chlorine (Cl) are usually found together as sodium chloride (NaCl) or common salt which serves to maintain activity levels in the body fluids and proper pressure in body cells as mentioned by Leaver (1983).

2.10.4. Magnesium:

The majority of the magnesium content of the body in the bones and is not easily mobilized (Leaver, 1983). Magnesium is also necessary for utilization energy in body and for bone growth (Plant and Animal Agriscience, 2008).

2.10.5. Iron:

Iron is an essential element for the formation of hemoglobin of red blood cells and plays an important role in the transportation of oxygen from the lungs to the

dory's cells and tissues it's also needed for metabolizing of B group vitamins (Mahindru, 2009).

2.11. Vitamins in milk and dairy products:

Vitamins are organic substance present in small amount in many foods including milk and dairy products. They are required for carrying out vital functions of the body. They are needed in small amounts but are essential for health and well being of the body (Leaver, 1983).

The principal classification of vitamins is based on their solubility in water. Water-soluble vitamins are B group (thiamin, riboflavin, niacin, biotin, panthothenate , folate, pyridoxine (and related substances, vitamin B6) and coalmine (and its derivatives, vitamin BI2) and ascorbic acid (vitamin C) while the fat-soluble vitamins are retinol (vitamin A), calciferols (vitamin D), tocopherols (and related compounds, vitamin E) and phylloquinone (and related compounds, vitamin K) (Fox and McSweeney , 1998).

2.11. 1. Vitamin A (Retinol):

Vitamin A is necessary for clear vision in dim light (McSweeney, 2004). Lack of vitamin A can lead to a night blindness. Besides it maintains the integrity of epithelial tissues. Vitamin A is present in milk products such as butter, ghee, whole milk, curd and all milk products including cheese (Mahindru, 2009).

2.11.2. Vitamin D (Claciferols):

Vitamin D is required for bone growth and calcium metabolisms. Its deficiency leads to rickets and osteomalacia. It plays an important role in the absorption of dietary calcium from the intestines and its deposition in bone (Mahindru, 2009). Vitamin D also functions like a hormone (Fox and McSweeney, 1998).

2.11. 3. Vitamin E and K:

Both are fat soluble vitamins widely distributed both in plant and animal products (Mahindru, 2009). Vitamin K functions as co-enzymes, while vitamin E is primarily an antioxidant (Fox and McSweeney, 1998).

2.11.4. Vitamin C (Ascorbic acid):

Ascorbic acid is chemically known as vitamin C. Being strong reducing agent ascorbic acid is involved in collagen synthesis, bone and teeth calcification and several other reactions in the body. Vitamin C deficiency causes Scurvy, characterized by weakness bleeding and defective bone growth. It also helps in the absorption of dietary iron by keeping it in the reduced form I.e. ferrous state. Fresh milk contains only small quantities of vitamin C (about 1 mg/100g. Concentrated milk products have 4-6.5 mg/100g (Mahindru, 2009).

2.12. Cheese microorganisms:

2.12.1. Yeasts and moulds:

2.12.1.1. Yeasts:

Yeasts are micro-organisms that can ferment sugars into alcohol, gas and other substances. They are about 5-10 times larger than bacteria. Yeasts usually grow in an acid environment; they need oxygen and they can withstand rather high concentrations of acids. In dairy products, yeasts are usually found in soured products like sour milk, buttermilk, sour whey and on the surface of the cheese. When present in large numbers they produce gas and they cause undesirable off flavors of the product (Ibraheem and Sheeba, 2004).

Growth of yeasts on milk products is attributed to their ability to utilize milk constituents such as proteins, fat, lactose and citrate (Fleet, 1990). The contamination of milk products, particularly cheeses with yeasts can take place through environment of cheese factories, like walls and shelves of ripening rooms, air, equipments, water, milk brine, etc. (Chapman and Sharpe, 1990 and Jay, 2000).

Yeasts play an important role in dairy products especially in the fermented milk products such as kefir and some yeasts are known for their inhibitory role against undesirable microorganisms (Mathara *et al*., 2004). Yeasts also affect the quality of fermented milk by improving flavor through the production of flavor and aroma compounds (Jakobsen and Narvhus, 1996).

Besancon *et al*., (1992) mentioned that yeasts and moulds are spoilage organisms resulting in flavor and texture deterioration including softening, discoloration and slim formation. Moreover, Roostita and Fleet (1998) stated that yeasts population greater than 10^6 CFU/gram sample were found in 46 (54 %) out of 85 and 16 (36%) out of 45 samples retailed camembert and blue-veined cheese, respectively. They also reported that yeasts population of 10^6-10^8 CFU/gram present when cheese was stored at either 25°C or 10°C. This population decrease on continued storage at 25° C but such decreases were not so evident on storage at 10° C.

The presence of yeasts in cheese is an indicative of low processing temperature, especially at filling or negligent sanitation. The major microbiological problem with these products is growth of yeasts and especially if free moisture is available at the surface (Marth and Steele, 2001). Yeasts themselves are not commonly the cause of defects in dairy products unless they ferment lactose. In this case they can grow rapidly and produce a typical yeasty or fruity flavor and obvious gas (Davis and Wilbey, 1990).

2.12.1.2. Moulds:

Moulds are string-like micro-organisms. To develop they need atmospheric oxygen and they thrive best in humid and acid conditions. Moulds multiply by forming spores. Their mobility to makes them an important source of infection. For some soft cheeses moulds are essential for ripening. In general moulds are harmless but some produce poisonous toxins (mycotoxins) such as aflatoxin (Pauline and Karin, 2006).

Moulds can grow well on the surfaces of cheeses when oxygen is present with the low pH being selective for them. In packaged cheeses, moulds growth is limited by oxygen availability, but some moulds can grow under low oxygen tension. Moulds commonly found growing in vacuum-packaged cheeses (Hocking and Faedo, 1992). Moulds in some cheese types can periodically cause economical problems. Usually if the moulds presence in the raw milk, they do not survive pasteurization, their presence in pasteurized milk and other milk products is caused by re-contamination during manufacturing (Jodral *et al.*, 1993).

Moulds growth on most cheese is undesirable, but certain moulds species are essential for ripening of some varieties of cheese. The most common ones found in cheese are Pencillium ssp., Cladosporium, Moucor and Getricum species (Nielson *et al*, 1997).

2.12.2. Coliforms:

Coliforms are Gram-negative aerobic and facultative anorexic short rod; the term includes *Escherichia coli* (*E.coli*), enterobacters, klebseilla in addition to the species from other genera of Enterobacteriacae (Quinn *et al*., 2002). The presence of coliforms bacteria in dairy products is suggestive of unsanitary condition or practices during production, processing and storage (Christen et *al.,* 1992). The main sources of these bacteria are intestinal track of warm blooded animals. Coliforms ferment lactose to lactic acid, carbon dioxide, hydrogen and breakdown milk protein given rise to unclean flavors and smell. In addition to that coliforms can cause serious trouble in cheese making; they liberate large amounts of gas resulting in fermented cheese with a bitter unclean taste (Sharon *et al.,* 1994). Walstra *et al*., (1999) stated that coliforms bacteria can grow only as long as sugar is available for fermentation because they can not fermented lactic acid and the growth of coliforms in cheese was prevented

by using fat souring starter culture that rapidly converts lactose to lactic acid, there by decreasing the pH in a short time to level that inhibits their growth.

According to (Ahmed, 1985) coliforms were not detected in market samples of cheese, but it can be detected in 30 % of the samples after storage for four months at 37ºC. Ahmed and Khalifa (1989) studied the microbiology of Sudanese cheese made from pasteurized milk; they found that the coliforms bacteria were present.

2.12.3. *Escherichia coli* (*E.coli*):

Escherichia coli (E. coli) is a bacteria that normally live in the intestines of the healthy people and animals, primarily cattle, it's a Gram-negative, facultative anaerobic and non spore making microorganism (Bettelheim, 2008). Most strains of these bacteria are harmless (Meng *et al*., 2001) but *E. coli* 0157:H7 is a specific strain of *E. coli* that causes illness. It was first recognized as a cause of illness during an outbreak of hemorrhagic colitis (severe bloody diarrhea) in 1982. The cause of that outbreak was traced to hamburgers contaminated with *E. coli* 0157:H7 bacteria. *E.coli* was also isolated from milk products including Cheese and Butter (Kulshrestha, 1990).

There are principally four different groups of *E. coli* which are pathogenic and have been implicated in food borne disease outbreaks. These are categorized based on virulence properties, mechanisms of pathogenicity and clinical symptoms and these categories include the enteropathogenic (EPEC), enteroinvasive (EIEC), enterotoxigenic (ETEC) and enterohaemorrhagic (EHEC) groups. The latter is the most important in terms of food borne illnesses. EHEC were first recognized as human pathogens in 1982 when *E. coli* O157:H7 was associated with two outbreaks of hemorrhagic colitis (Riley *et al*., 1983).

Human infection with *E. coli* O157:H7 can result in non-bloody diarrhea and hemorrhagic colitis in which the stools contain red blood. It is also the leading cause of hemolytic uremic syndrome which causes renal failure in children. The pathogenicity of this organism seems to be connected with the ability to produce attaching and effacing adherence to the large bowel and the production of serotoxin (Griffin and Tauxe, 1991).

E. coli is responsible for several outbreaks of diarrhea in children and adults after ingestion of contaminated milk and dairy products. Different studies showed that 1- 5% of food-borne infections were related to consumption of milk and dairy products, about 53% of cases of the food-borne infections caused by contaminated cheese and the enteropathogenic *E. coli* (EPEC) is the causative agent of 18.33% of these cases (Schrade and Yager ,2001). Enteropathogenic *E. coli* EPEC strains have been implicated in food-borne human illnesses, especially as an important agent of infantile diarrhea in developing countries (Silva *et al*., 2001).

Although outbreaks involving other pathogens have occurred the only domestic outbreak of *E. coli* O157:H7 illness linked to the consumption of cheese occurred in 1998 in Wisconsin, where vats used to make raw milk Cheddar cheese were inadvertently used to make fresh cheese curds. These curds were incorrectly labeled and sold as ‘‘pasteurized’’ and eventually sickened 55 people (Goh *et al.*, 2002 and McIntyre *et al*., 2002). The first confirmed outbreak of *E. coli* O157:H7 infection in Canada associated with raw milk hard cheese occurred in 2002, aged Gouda cheese was found to be contaminated with the pathogen (Honish *et al* ., 2005).

2.12.4. Lactic acid bacteria:

2.12.4.1. Lactobacilli:

Lactobacilli are a genus of Gram-positive facultative anaerobic bacteria. They are a major part of the lactic acid bacteria group; they have been given this name because most of its members convert lactose and other sugars to lactic acid . In humans they are present in gastrointestinal tract, where they are symbiotic and make up a small portion of the gut flora. Many species are prominent in decaying plant materials. The production of lactic acid makes its environment acidic which inhibits the growth of some harmful bacteria (Sabinsa Corporation, 2000).

Lactobacilli vary in morphology from long, slender rods to short coccobacilli, which frequently form chains. Their metabolism is fermentative; some species are aero tolerant and may utilize oxygen through the enzyme flavor protein oxidize, while others are strictly anaerobic. While spore bearing lactobacilli are facultative an aerobics, the rest are strictly anaerobic. The growth is optimum at pH 5.5-5.8 and the organisms have a complex nutritional requirements for amino acids, peptides, nucleotide bases, vitamins, minerals, fatty acids and carbohydrates (Alfa-laval Dairy Hand Book, 2005). Lactobacilli can grow in the cheese milk and reach high count within 6 weeks and it may cause various defects such as gassy and putrid flavor and often, excessive openness and other flavor and texture defects (Walstra *et al.*, 1999).

Lactobacilli are used as starter culture in the manufacturing of yoghurt and cheese such as Mozzarella and other cheeses. They are also used as starter adjunct to promote faster ripening of Cheddar and similar cheeses and to reduce the incidence of bitterness and as probiotics in yoghurt products. In addition to that there are several postings concerning the control of bitterness in Cheddar and Gouda cheese (James, 2013).

2.12.4.2. Streptococci:

Streptococci are a genus of Gram-positive bacteria. Under the microscope they appear round (cocci) which tend to occur in chain (Ryan and Ray, 2004). The

only *Streptococcus* sp. useful in dairy fermentation is *S. thermophilus*. This microorganism is genetically similar to oral streptococci (*S. salivarius*) but can still be considered a separate species, *S. thermophilus* is differentiated from other streptococci by its heat resistance, ability to grow at 52°C and ability to ferment only a limited number of carbohydrates (Axelsson, 1993).

Some strains of streptococci can cause defects in chesses and other dairy products because they grow at 45ºC and survival thermalization and low pasteurization of milk. During these heat treatments they may attached to the wall of the cooling section in the heat exchanger and multiply rapidly depending on their initial number in the milk cheese and the continuous use of heat exchange for long time without cleaning may heavily contaminate the cheese and unclean and yeasty flavor may develop as a result of streptococci growth on the cheese curd (Walstra *et al*., 1999).

2.12.5. *Staphylococcus aureus:*

Staphylococcus aureus is a non spore forming, facultative anaerobic Gram-positive coccus shaped bacterium that is both catalase and coagulase positive and they were first described in 1897 (Forsythe, 2000). Cells are typically arranged singly, paired or in grape-like clusters (Le Loir *et al.*, 2003). *Staphylococcus aureus* exists in air, dust, sewage, water, milk and food. Although this pathogen is transmitted to food from human sources, equipments and environmental surfaces can also be sources of contamination. Foods that are frequently associated with staphylococcal food poisoning include milk and dairy products. The type of food poisoning caused by *Staphylococcus aureus* is characterized by nausea, vomiting, and abdominal cramps and often with diarrhea (Cliver, 1990).

Staphylococcal food poisoning occurs not as the result of the ingestion of the organism itself, but through ingestion of one or more of the staphylococcal enterotoxins produced by some strains of *S. aureus* (Le Loir *et al.*, 2003).

Staphylococcus aureus is involved in essentially all staphylococcal food borne disease outbreaks. A recent survey revealed that *Staphylococcus aureus* was involved in 15 % of recorded food borne illnesses caused by dairy products in eight developed countries (De Buyser *et al*., 2001).

According to the same report *Staphylococcus aureus* was responsible for more than 85 % of the dairy borne diseases in France. *Staphylococcus aureus* can grow in many food types and in combination with its ecological niche, its incidence in processed, manipulated and fermented foods makes it an important food borne pathogen. Other contamination sources of *S. aureus* may be the farm or the food processing environment (Borch *et al.*, 1996 and Jorgensen *et al.*, 2005). *Staphylococcus aureus* can also be an udder pathogen and is often isolated in mastitis milk from cows, sheep and goats (Bergonier *et al.*, 2003; Jorgensen *et al.*, 2005 and Jakobsen *et al.*, 2011).

Outbreaks of staphylococcal poisoning have been linked to milk and milk products for over 100 years with *S. aureus* emerging as a major milk borne pathogen of concern by the 1930s (Ryser, 2001).

2.13. Cheese yield:

Cheese yield is defined as the amount of cheese expressed in kilograms obtained from 100 kg of milk (Banks *et al.*, 1981).

2.14. Factors affecting cheese yield:

Cheese yield is affected by many factors including milk composition , genetics variation , physiological factors , lactation stage , seasonal variations, type of milk , processing conditions , storage of milk , standardization of milk ,types of starter culture used , heat treatments of milk , homogenization of milk, types of coagulant used , curd firmness , curd handling systems and others factors

(Yardibi *et al*,.2009 ; Everett and Auty ,2008 ; Najaf *et al.*, 2008 ; Paolo *et al.*, 2008 and Damian *et al.*, 2008).

Chapter Three

Materials and Methods

The present study was conducted during 2013 at the Laboratory of the Department of Dairy Science and Technology, College of Animal Production Sciences and Technology, Sudan University of Science and Technology. In this Study four treatments were carried out. First treatment is a control in which fresh cow's full cream milk was processed into cheese without additive. In the second (Cw1), third (Cw2) and fourth (Cw3) treatments 0.5, 0.75 and 1% of cassava powder were added respectively to the fresh cow's full cream milk before pasteurization. Each treatment was made into triplicates.

3.1. Materials:

3.1.1. Source of milk:

One hundred twenty liters (120 liters) of fresh cow's full cream milk were purchase from a private farm at Khartoum North.

3.1.2. Source of cassava:

Cassava roots were brought from Konyo-Konyo market at Juba and then were cut into small pieces and dried under the sun light for 1-3 days, then grinded to a fine powder (flour) before added to the milk.

3.1.3. Source of salt and starter:

A fine commercial salt (Sodium chloride) and a commercial starter composed of (*Streptococcus thermophillus* and *Lactobacillus bulgaricus*) was purchase from local markets.

3.1.4. Source of rennet:

Powder rennet was obtained from Chr-Hansen Laboratories (Copenhagen, Denmark).

3.1.5. Source of calcium chloride:

A fine Calcium chloride powder of good quality was purchased from Lab line International Company, Khartoum-Sudan.

3.1.6. Source of plastic buckets:

The plastic buckets of (500 gram) were brought from Hala plastic factory-Omdurman.

3.2. Methods:

3.2.1. Cheese manufacturing:

Cheese was manufactured according to the method described by (Ibrahim, 2003 and Ahmed and Kalifa, 1989) with some modifications. One hundred and twenty liters (120 liters) of fresh clean cow's full cream milk was divided into four equal volumes (30 liters each) and kept in four separate tanks. The first volume was left free without any additive of cassava powder, while in the other three volumes cassava powder was added at the rates of 0.5, 0.75 and 1% to the milk respectively. The different milk samples were pasteurized at 72^{o}C for 1 minute. The milk samples were then transferred into stainless steel containers for cheese manufacturing and then cooled to 42^{o}C. Commercial starter of (*Streptococcus thermophillus* and *Lactobacillus bulgaricus*) in the ratio of 1:1% concentrate was added at the level of 1 % (W/v). The milk was stirred gently for 15 minutes to avoid creaming before renneting. Rennet powder (1 gram /50 liters of milk) was dissolved in 50 ml of distilled water and added to the milk at 40^{o}C. Fine calcium chloride was added at the levels of 0.02 % immediately. Milk was then stirred for 20 minutes and then left undisturbed for 3 hours to develop curd. The curd was cut into small cubes (2.5x2.5x2 cm). After draining, salt at 2% (w/v) was mixed with the curds. The curd was poured into small clean wooden molds lined with cheese cloth and pressed by 30 kg weight overnight. The next day, brine solution was prepared by adding salt to the

collected whey (8 % w/v) and pasteurized at 72°C for 1 minute and cooled to 40°C. The pressed cheese was cut into small cubes and then transferred to the triplicate sterile plastic buckets containers filled with whey. The containers were sealed and stored at room temperature for 90 days. Physicochemical, microbiological and sensory evaluations of cheese samples were carried out at 0, 30, 60 and 90 days interval.

3.2.2. Physicochemical analysis of milk and cheese:

The chemical composition of the milk was determined after heat treatment of milk (Pasteurization).

3.2.2.1. Total solids content:

Total solids content was determined according to the modified methods of (AOAC, 2009). Two grams of cheese (3 ml milk) samples were placed in a clean dried flat-bottomed aluminum dish. The weight of sample and the dish were recorded and the dishes were heated on steam bath for 10-15 minutes and placed to air oven at 100°C for three hours. The dishes were transferred to dissector to cool and weighed. Heating, cooling and weighing were repeated several times until the difference between the successive weighing was less than 0.5 mg. The total solids were calculated as follows:

$$Total\ Soilds\ \% = \frac{W_1}{W_0} X100$$

Where:

W1= Weight of samples after drying.

W0= Weight of sample before drying.

3.2.2.2. Fat content:

Fat content was determined by Gerber method according to AOAC (2009) as follows:

Ten ml of sulfuric acid (density 1.815 gm/ml at 20°C) were poured into a clean Gerber tube followed by the addition of 3 gram minced cheese (10.94ml milk) sample. The tubes were then thoroughly mixed till no white particles were seen, centrifuged at 1100 revolution per minutes (rpm) and transferred to water bath at 65°C for three minutes. The column of the fat was then recorded immediately.

3.2.2.3. Crude protein:

The protein content was determined by Kjeldahl methods according to AOAC (2009). In Kjeldahl flask 3 grams cheese (10 ml of milk) were placed. Two Kjeldahl tubes, 1 gm $NaSo_4$ and equivalent of 0.1 mg Hg) were added. Twenty five milliliters of concentrated sulfuric acid (density of 1.86 mg/ml at 20°C) were added to the flask. The mixture was then digested until a clean solution was obtained (2.5 hours) and the flask were removed and left to cool.

The digested sample was poured into a volumetric flask (100 ml) and diluted to 100 ml with distilled water. The distillate was received in a conical flask containing 25 ml of 2 % boric acid plus 3 drops of indicator (bromocerol green plus methyl red). The distillation was continued until the volume in the flask was 75 ml. The flask was removed from the distilator.

The distillator was then titrated against 0.1N HCl until the end point was obtained (red color). Protein content was calculated as follows:

$$\text{Nitrogen \%} = \frac{\text{Tx0.1x0.014x20}}{\text{Weight of sample}} X100$$

Protein (%) = Nitrogen (%) x6.38

Where:

T= Titration figure

0.1 = Normality of HCl

0.014 = Atomic weight of nitrogen 2/1000

20=Dilution factors

3.2.2.4. Ash:

The ash content was determined according to AOAC (2009). Two grams of cheese and (10 ml of milk) were weighed into suitable clean dry crucible and evaporated to dryness on steam bath, and the crucibles were placed in muffle furnace at 550°C for 1.5-2 hours, cooled in dissector and weighed. The ash content was calculated as follows:

$$Ash\ \% = \frac{W_1}{W_0} X100$$

Where:

W1= Weight of ash

W0= Weight of sample

3.2.3. Biochemical procedures:

3.2.3.1. Titratable acidity:

Titratable acidity was determined according to AOAC (2009). Ten grams of cheese (10 ml of milk) were weighed and placed in a conical flask and distilled water at (40°C) was added until the volume in the flask was 105 ml. The sample was vigorously agitated and filtered through filter paper (Whatman No.41) Twenty five milliliters of the filtrate were pitted into porcelain dish and 5 drops of phenolphthalein indicator were added. The sample was titrated against 0.1 NaOH till a faint pink color that lasted for 30 seconds was obtained. The titration was divided by 10 to get the percent lactic acid, the acidity for cheese and milk was calculated as follows:

$$\text{Titratable acidity(\% lactic acid)} = \frac{Tx4}{W}$$

Where:

T= Titration figure.

W= Weight of sample

3.2.3.2. Total volatile fatty acids (TVFA):

Total volatile fatty acids content of the cheese samples were determined by the direct distillation method of (Kosikowski, 1982). Ten grams of cheese were placed in a mortar and grounded with successive portions of 10% sulfuric acid until the cheese was completely emulsified then transferred to 500 ml Kjeldahl flask. The addition continued until the volume of the acid added to the sample reached 25 ml. About 17.5 grams of magnesium sulphate were added to the contents in the flask, followed by few glass beads, 250 ml of distilled water and the contents distilled. Distillation was terminated when 280 ml of the distillate were collected. The inside tube of the condenser was rinsed with 12.5 ml of neutral alcohol to remove the insoluble volatile acids combined with distillate and titrated with 0.1 N NaOH. The total volatile fatty acids contents were expressed as ml of 0.1 N NaOH that neutralized the distillate from 100 grams of cheese.

3.2.3.3. pH:

The pH value was determined in 10 % solution of cheese sample for milk direct as described by Newlander and Atherton (1964) using pH meter model- Pasl Muchen 15-1260/7 Germany.

3.2.4. Vitamin C and minerals content of the cheese

3.2.4.1. Vitamin C content:

Vitamin C was estimated by the colorimetric method according to AOAC (2009) as follows: 0.5 ml of homogenate milk or cheese samples from clear

zone were taken, 0.5 ml of distilled water, 1.0 ml of 20% TCA (Trichloro Acetic Acid) were added, mixed thoroughly and centrifuged for 20 minutes, then 1.0 ml supernatant, 0.2 ml of 2, 4 dinitro phenyl hydrazine -Thiourea - copper sulphate reagent (DTC reagent) was added and incubated at 37°C for 3 hours. Then 1.5 ml of 65% sulphuric acid was added mixed well and was allowed to stand at room temperature for another 30 minutes. The color developed was read at 520 nm (nanometers) by Atomic Absorption spectrometer.

3.2.4.2. Calcium, phosphorus, sodium and potassium determination:

Calcium, phosphorus, sodium and potassium contents of the samples were determined by Atomic Absorption Spectrometer according to Perkin Elmer (1994) and AOAC (2009). Two grams of cheese was maintained in muffle furnace at 550ºC for 4 hours. Samples were cooled and 10 ml of 3N HCL was added. Covered with watch glass and boiled gently for 10 minutes. Then cooled, filtered, diluted to volume (100m) with distilled water and taken for determination of phosphorus (P) sodium (Na) potassium (K) and for the determination of calcium 1 ml of 1 % lanthanum chloride was added to the final dilution.

$$\text{Mg mineral / 100 mg sample} = \frac{\text{mg/L volume used x100}}{\text{1000xwt.of sample}}$$

3.2.5. Microbiological analysis:

3.2.5. 1. Sterilization of equipments:

Glassware such as flask , test tubes Petri dishes , pipettes and bottles were sterilized in hot oven at 170ºC for two hours , whereas distilled water was sterilized by autoclaving at 121ºC for 15 minutes (Marshall , 1992).

3.2.5. 2. Preparation of sample dilution:

Eleven grams from a homogenous cheese sample were added to 99 ml of sterile distilled water in a clean sterile flask then shaken to make 10^{-1} dilution. One ml from the dilution (10^{-1}) was aseptically transferred to 9 ml sterile distilled water. This procedure was repeated to make serial dilutions of 10^{-1} to 10^{-8} (Houaghtby *et al*., 1992).

3.2.5. 3. Preparation of media:

All media were obtained in a dehydrated form and stored in a hygroscopic environment in a cool dry place, away from light and prepared according to the manufactures instructions.

3.2.5. 4. Total bacteria count:

The plate count agar medium was used for the determination of the total bacteria count according to Houghtby *et al.,* (1992) and Ramakant (2006).

3.2.5. 4. 1. Preparation of the media:

The manufacture's instructions were followed by dissolving 23.5 gram of powder in a litter of distilled water, heated to boiling point and sterilized in an autoclave at 121ºC for 15 minutes (Frank *et al.*, 1992).

3.2.5. 4. 2. Plating:

From each dilution , 1 ml was transferred into sterile Petri dishes (duplicate) followed by addition of 15-18 ml melted , cooled (45-46ºC) plate count agar , mixed thoroughly by rotating the dishes first in one direction and then in the opposite direction . When the medium has solidified, the dishes were incubated in an inverted position at 32±1ºC for 48±3 hours.

3.2.5. 4. 3. Counting:

Plates contain 25-250 colonies were selected and counted using colony counter. The number of colony-forming units (cfu) in each dilution was obtained by multiplying the number of colonies in the reciprocal of each dilution.

3.2.5. 5. Lactobacilli count:

MRS agar was used for the enumeration of Lactobacilli according to Frank *et al*., (1992).

3.2.5. 5. 1. Preparation of the media:

The medium was prepared by suspending 70 gm of the powder in one liter of distilled water, then boiled until dissolved completely and sterilized by autoclaving at 121^{o}C for 30 minutes.

3.2.5. 5. 2. Plating:

Point one ml quantities of each sample decimal dilutions, 10^{5} was streaked in dried plat of MRS agar. The culture was incubated at 35^{o}C for 48 hours.

3.2.5. 5. 3. Counting:

The colonies were counted by colony counter.

3.2.5. 6. Streptococci count:

M17 agar medium (Merck-15108) was used to determine streptococci count according to Oksuztepe *et al*., (2005). From each 0.2 ml of chemical dilution 10^{2} and 10^{6} were streaked on dried duplicate plates of the media, the plates were incubated at 37^{o} C for 48 hours colonies of streptococci were counted by colony counter and recorded.

3.2.5. 7. Yeasts and Moulds count:

Potato dextrose agar medium was used for the enumeration of yeasts and moulds count according to Frank *et al*., (1992) and Marshall (1993).

3.2.5. 7. 1. Preparation of the medium:

The medium was prepared according to Frank *et al*., (1992). The manufacture's instructions were followed by dissolving 39 grams in a liter of distilled water, heated to boiling and sterilized in an autoclave at 121ºC for 15 minutes. The medium was then left for 15 minutes to cool to 45ºC , and Tartaric acid (1 ml/100 ml) was added to reduce the pH , then the medium was purred into sterile petri dishes (18-20 ml) and left to solidify.

3.2.5. 7. 2. Plating:

A sample from each dilution (1 ml) was deposited on to the solidified Potato dextrose agar medium. The sample was spread over the surface of the agar medium and the dishes were then inverted and incubated at 25ºC for 3-5 days.

3.2.5. 7. 3. Counting:

The plates contain 15-150 cfu were selected and counted using colony counter.

3.2.5. 8. Coliforms bacteria count:

The count was performed according to Christen *et al*., (1992) and Marshall (1993) Using MacConkey agar medium.

3.2.5. 8.1. Preparation of the medium:

The manufacture's instructions were followed by dissolving 51.5 gm of powdered medium in a litter of distilled water, heated to boiling point and sterilized in autoclave at 121ºC for 15 minutes (Christen *et al*., (1992).

3.2.5. 8.2. Plating:

From each dilution 1 ml was transferred into Petri dishes (duplicate) followed by addition of 15-18 ml melted, cooled medium (45-46ºC), mixed thoroughly by rotating the dishes first in one direction and then in the opposite direction.

When medium was solidified, the dishes were incubated in inverted position at 32±1ºC for 24±2 hours.

3.2.5. 8.3. Counting:

Plates containing 20-200 colony forming units (cfu) were selected and counted using a colony counter, and the number of the colonies were obtained by multiplying number of colonies in each dilution by reciprocal of the dilution.

3.2.5. 9. *Staphylococcus aureus* count:

The count was performed according to Flowers *et al.*, (1992) and Rayman *et al*., (1988) using Baird Parker Agar medium.

3.2.5. 9. 1. Preparation of the medium:

The manufacture's instruction were followed by dissolving 63.0 gm in 950 ml of distilled water, heated to boiling point and sterilized in an autoclave at 121ºC for 15 minutes. The medium was cooled to 50ºC and 50 ml of sterile Egg yolk emulsion and 3 ml of sterile 3.5 % potassium telluride (t) solution were aseptically added. The medium was poured into sterile dishes (15-18) ml and left to solidify (Frank *et al.*, 1992).

3.2.5. 9. 2. Plating:

From each dilution 1 ml was aseptically transferred into Petri dish and spread over the surface of the agar medium using a sterile bent glass rod. The Petri dish were maintained in an upright position until the inoculums was absorbed by the agar medium then the dishes were inverted and incubated at 35ºC for 48 hours.

3.2.5. 9. 3. Counting:

Plates containing 20-200 colony forming units (cfu) were selected and counted using a colony counter. The number of colony forming units (cfu) in each

dilution was obtained by multiplying the number of colonies in the dishes by the reciprocal of the dilution.

3.2.5. 10. Cheese yield:

The cheese yield was determined according to Paolo *et al.*, (2008); Walstra, *et al*., (1999) and Abdel Moneim *et al.*, (2012) as follow:

$$\text{Yield} = \frac{\text{Wight of cheese}}{\text{Wight of sample}} X100$$

3.2.5. 11. Sensory characteristics:

The sensory characteristics of the cheese samples were judge by 10 untrained panelists for color, flavor, texture, taste, saltiness and over all acceptability by using sensory evaluation sheet (Appendix I) according to Larmond (1987).

3.2.5. 12. Statistical analysis:

Statistical analysis was done by using Statistical Package for Social Sciences (SPSS, 2004) program. General Linear models were used to estimate the effect of different levels of cassava powder, storage periods and the interactions between them on the chemical composition, microbiological quality and sensory characteristics of the cow's milk white soft cheese. Least Significance Difference (LSD) was used for mean separation between the treatments. The level of significance (0.05) was used in this study.

Chapter Four

Results

4.1. Results:

4.1.1. The physicochemical characteristics of pasteurized milk, cassava powder and microbiological evaluation of cheese milk used in this study were presented in tables 2, 3 and 4 respectively.The results in these tables showed that the concentration of the minerals in the pasteurized milk were; 11.72 Mg/L, 9.23 Mg/L, 7.94 Mg/L and 4.30 Mg/L for Ca, K, P and Na respectively. The chemical composition of cassava powder was as follows; 4.26 Mg/L K ; 3.68 Mg/L P; 2.59 Mg/L Ca and the lowest average amount was for Na 0.72 Mg/L (Table 3). The total bacteria in the pasteurized milk was very low, $3.0x10^3$, while coliforms , lactic acid bacteria , *Staphylococcus auerus* and yeasts and moulds were not detected in the pasteurized milk (Table 4).

4.1.2. Effect of different levels of cassava powder on the physicochemical characteristics of the Sudanese white soft cheese:

Results in table 5 illustrated the effects of different levels of cassava on physicochemical characteristics of cow milk cheese. The results indicated that there were significance differences ($P<0.05$) in the total solids content of the treatments.

The data showed that the highest total solids (56.31±9.20 %) was in the control cheese while the lowest one (53.95±8.93 %) was recorded in the cow milk cheese with 1 % cassava powder (Table 5).

Fat contents of the cheese (Table 5) were significantly different ($P<0.05$). The highest fat (21.28±1.57 %) was recorded in the cheese with 1 % cassava while the lowest value (20.25±1.84%) was found in the control cheese.

The results (Table 5) indicated that crude protein contents was significantly ($p<0.05$) higher (18.54±4.38 %) in the cheese with 1 % Cassava, however the lower value (16.90±5.08 %) was found in the control cheese.

The titratable acidity of the cheese samples was significantly ($P<0.05$) affected by the different levels of cassava powder between all the treatments. The highest acidity (0.94±0.37%) was scored by the cheese with 0.75 % of cassava while the lowest one (0.91±0.37 %) was scored by the control cheese (Table 5).

The results showed that there were significant difference ($P<0.05$) in the total volatile fatty acids between all the treatments. The highest total volatile fatty acids (11.05±2.92 0.1 N mL NaoH/100 gms cheese) was in the cow's milk cheese with 1 % cassava , while the lowest one (7.70±3.97 0.1 N mL NaoH/100 gms cheese) was in control cheese (Table 5).

It was observed that no significant ($P>0.05$) variations were found in the pH of the cheese samples in all treatments. The highest pH value (3.48±0.59 %) was in the control cheese and that with 0.75 % cassava powder, while the lowest pH (3.43±0.55 %) was for the cow's milk cheese with 1 % cassava.

The results indicated that there were no significance difference ($P>0.05$) in the ash contents between all treatments. The highest ash (6.38±8.46%) was in the cow's milk cheese with 1 % cassava; however the lowest value (4.49±0.60 %) was in the cow's milk cheese with 0.5 % cassava (Table 5).

4.1.3. Effect of different levels of cassava powder on vitamin C and minerals contents of the Sudanese white soft cheese:

Data in table 6 illustrated the effects of different levels of cassava powder on vitamin C and minerals contents of the cow's white soft cheese. Vitamin C, calcium (Ca) and phosphorus (P) significantly ($P<0.05$) affected by the different levels of cassava powder, while there were no significance difference ($P>0.05$) in sodium (Na) and potassium (K).

The results (Table 6) indicated that significant variation ($P<0.05$) was found in the vitamin C content between all treatments. The highest vitamin C (3.61±1.09 Mg/L) was in the cow's milk cheese with 1 % cassava, while the lowest one (3.24±1.07 Mg/L) was recorded in the control cheese.

Table 2: Chemical composition of the pasteurized milk used in the study:

Moisture %	T.S %	Ash %	C.P%	Fat %	V.F.A %	Acidity %	pH %	Na Mg/L	Ca Mg/L	K Mg/L	P Mg/l	Vitamin C mg/L
89.5	10.5	0.85	3.78	3.8	5.74	0.21	6.5	4.30	11.72	9.23	7.94	5.21

Table 3: Chemical composition of the cassava powder used in the study:

Moisture%	D.M%	Ash %	C.P%	E.E %	C.F %	N.F.E %	pH %	Na Mg/L	Ca Mg/L	K Mg/L	P Mg/L	Vitamin C mg/L
7.25	92.75	5.2	16.75	3.0	3.02	65.13	6.75	0.72	2.59	4.26	3.68	2.75

Table 4: Microbiological analysis of the pasteurized milk used in the study:

Total viable bacteria cfu/ml	Coliforms cfu/ ml	Lactic acid bacteria cfu/ml	*Staphylococcus aureus* cfu/ml	Yeast and moulds cfu/ml
$3.0x10^{3}$	-ve(no growth)	- ve(no growth)	-ve (no growth)	-ve(no growth)

Cfu= Colony forming unit

Table 5: Effect of different levels of cassava powder on physicochemical characteristics of the Sudanese white soft cheese:

Treatments	Physicochemical characteristics						
	Total solids %	**Fat %**	**C.P %**	**Acidity %**	**TVFA (0.1 N mL NaoH/100 gms cheese)**	**pH %**	**Ash %**
Control	56.31±9.20[a]	20.25±1.84[d]	16.90±5.08[d]	0.91±0.37[d]	7.70±3.97[d]	3.48±0.59	4.53±0.53
Cw1	55.26±8.90[b]	20.77±1.84[c]	17.85±5.18[c]	0.92±0.36[c]	10.06±3.50[c]	3.48±0.55	4.49±0.60
Cw2	54.73±9.11[c]	20.95±1.71[b]	17.94±5.00[b]	0.94±0.37[a]	10.37±2.23[b]	3.48±0.59	4.58±0.63
Cw3	53.95±8.93[d]	21.28±1.57[a]	18.54±4.38[a]	0.93±0.37[b]	11.05±2.92[a]	3.43±0.55	6.38±8.46
L .S	***	***	***	***	***	NS	NS

Mean values bearing different superscripts within rows are significantly different (P<0.05)
L.S= Levels of significance
Control = Cheese without cassava powder
Cw1=Cheese with 0.5 % cassava
Cw2= Cheese with 0.75 % cassava
Cw3=Cheese with 1 % cassava
NS= Not significance

The calcium (Ca) content of the cow's milk cheese was significantly different ($P<0.05$) between all treatments. The highest (Ca) content (10.47±1.27 Mg/L) was for the cow's milk cheese with 1 % cassava, while the lowest one (9.98±1.33 Mg/L) was found in control cheese (Table 6).

The phosphorous (P) content of the cheese samples was affected significantly ($P<0.05$) by the different levels of cassava powder between all treatments. The highest phosphorous (5.07±1.22 Mg/L) were recorded in the cheese with 1 % cassava (Cw3) while the lowest one (4.82±1.86 Mg/L) was found in the cheese milk with 0. 5 % cassava (Table 6).

Results in (Table 6) showed that there were no significance difference ($P>0.05$) in sodium (Na) and potassium (K) contents between all the treatments. The highest sodium contents (52.50±1.79 Mg/L) were found in the cow's milk cheese with 1 % cassava, while the lowest one (52.03±1.03 Mg/L) was found in the control cheese. The highest potassium (8.16±1.53 Mg/L) was found in the cheese made from 1% cassava, while the lowest one (7.95±1.37 Mg/L) was recorded in the cheese with 0.5 % cassava.

4.1.4. Effect of different levels of cassava powder on the microbiological characteristics of the Sudanese white soft cheese:

Results in table **7** illustrated the effect of different levels of cassava powder on the microbiological characteristics of the white cheese. Total viable bacteria, lactobacilli, streptococci, yeasts and moulds and *Staphylococcus aureus* significantly ($P<0.05$) affected by the different levels of cassava powder, while there were no significance difference ($P>0.05$) on coliforms counts.

Table 6: Effect of different levels of cassava powder on vitamin C and minerals contents of the Sudanese white soft cheese:

Treatments	Vitamin C and minerals contents				
	Vitamin C mg/L	**Ca mg/L**	**P mg/ L**	**Na mg/L**	**K mg /L**
Control	3.24±1.07 [d]	9.98±1.33 [d]	4.88±0.97 [c]	52.03±1.03	8.03±1.18
Cw1	3.58±1.11 [c]	10.11±1.38 [c]	4.82±1.86 [d]	50.46±9.76	7.95±1.37
Cw2	3.60±1.11 [b]	10.29±1.26 [b]	4.97±1.39 [b]	52.22±1.56	7.99±1.44
Cw3	3.61±1.09 [a]	10.47±1.27 [a]	5.07±1.22 [a]	52.50±1.79	8.16±1.53
L.S	***	***	*	NS	NS

Mean values bearing different superscripts within rows are significantly different (P<0.05)
L.S= Levels of significance
Control = Cheese without cassava powder
Cw1=Cheese with 0.5 % cassava powder
Cw2= Cheese with 0.75 % cassava powder
Cw2= Cheese with 1 % cassava powder
NS: Not significance

The highest total viable bacteria count (7.35±0.57 cfu/gm) was observed in the cow's milk cheese with 0.5 % cassava, while the lowest one (6.63±0.82 cfu/gm) was found in the control cheese.

The highest lactobacilli count (4.25±1.09 cfu/gm) was recorded in the control cheese, whereas the lowest one (3.95±0.52 cfu/gm) was in the cow's milk cheese with 0.75 % cassava (Table **7**).

Streptococci count (Table **7**) were affected significantly ($P<0.05$) by the different levels of cassava powder. The highest streptococci (4.27±1.16 cfu/gm) were recorded in the control cheese, while the lowest one (3.63±0.79 cfu/gm) was found in the cow's cheese milk with 0.5 % cassava.

Results in (Table **7**) demonstrated that significant differences ($P<0.05$) were found in the yeasts and moulds count of the cow's milk cheese between all treatments. The highest yeasts and moulds count (5.75±0.67 cfu/gm) was recorded in the control cheese, while the lowest one (5.50±0.77 cfu/gm) was found in the cow's milk cheese with 0.5 % cassava.

The highest coliforms count (2.66± 1.88 cfu/gm) was found in the cow's milk cheese with 1 % cassava, while the lowest count (2.64±1.78 cfu/gm) was for the control cheese.

Table 7: Effect of different levels of cassava powder on microbiological quality (Log cfu/gm) of Sudanese white soft cheese:

Treatments	Microbiological quality of the cheese					
	Total viable bacteria(cfu/gm)	**Lactobacilli (cfu/gm)**	**Streptococci (cfu/gm)**	**Yeasts & moulds(cfu/gm)**	**Coliforms (cfu/gm)**	***Staphylococcus aureus*(cfu/gm)**
Control	6.63±0.82 [d]	4.25±1.09 [a]	4.27±1.16 [a]	5.75±0.67 [a]	2.64±1.78	4.54±0.44 [a]
Cw1	7.35±0.57 [a]	3.97±0.50 [b]	3.63±0.79 [d]	5.50±0.77 [d]	2.65±1.87	4.50±0.36 [d]
Cw2	7.32±0.60 [c]	3.95±0.52 [d]	3.76±0.75 [c]	5.54±0.81 [c]	2.65±1.88	4.50±0.44 [c]
Cw3	7.33±0.60 [b]	3.96±0.50 [c]	3.79±0.76 [b]	5.60±0.77 [b]	2.66±1.88	4.53±0.41 [b]
L .S	***	***	***	***	NS	**

Mean values bearing different superscripts within rows are significantly different (P<0.05).
L.S= Levels of significance
Cfu=Colony forming units
Cw1=Cheese with 0.5 % cassava
Cw2= Cheese with 0.75 % cassava
Cw3=Cheese with 1 % cassava
NS: Not significance

Results in (Table **7**) indicated that there were significance difference (P<0.05) in the *Staphylococcus aureus* count. The highest *Staphylococcus aureus* (4.54±0.44cfu/gm) was found in control cheese, while the lowest one (4.50±0.36 cfu/gm) was in the cow's milk cheese with 0.5 % cassava.

4.1.5. Effect of the different levels of cassava on sensory characteristics of the Sudanese white soft cheese:

Table 8 showed the main effect of different levels of cassava on the sensory characteristics of cow's milk cheese. Significant variations (P<0.05) were found in the color, texture and saltiness of the cheese samples, however, no significances differences (P>0.05) were observed in flavor, taste and over all acceptability of the cheese samples.

The control cheeses showed highest color scores (6.90±2.01), while the lowest one (5.05±2.41) was for the cheese with 1 % cassava. The best values for the texture (6.56±2.07) was in the control cheese while the lowest one (5.55±1.75) was in the cheese with 0.75 % cassava.

The cheese with 0.5 cassava recorded the highest saltiness (6.85±1.66), while the control cheese recorded the lowest value (5.24±2.42). The control cheese obtained the highest acceptability than other cheese with 0.5, 0.75 and 1 % cassava respectively (Table 8).

4.1.6. Effect of storage period on physicochemical characteristics of the Sudanese white soft cheese:

Result in table (9) shows the main effect of storage period on physicochemical characteristics of cow's milk cheese.

The total solids content of the cheese was significantly (P<0.05) increased from (41.98±0.88 %) at day zero to (65.65±1.35 %) at day 90.

The fat content of the cow's milk cheese was affected significantly (P<0.05) by the storage period (Table 9**)**. The highest fat content (23.29 ±0.26%) was found

at day 30 while the lowest one (18.57±0.62%) was at day 90. The crude protein content of white cheese samples was significantly (P<0.05) increased to (23.27±0.53%) at day 30 as the storage progressed and then it decreased to (11.23±1.39%) at day 90 (Table 9).

It was clear (Table 9) that the titratable acidity of the cheese samples increased significantly (P<0.05) as the storage period progressed. It was increased from (0.41±0.01%) at day zero to (1.36±0.02%) at the day 90. The pH of the cheese samples in this study was affected significantly (P<0.05) by the storage period. It was decreased from (4.21±0.08%) at day zero to (2.71±0.10 %) at day 90 (Table 9).

Data in table 9 showed that the total volatile fatty acids were increased significantly (P<0.05) with the advancement of storage period. They were increased from (6.33±1.58 0.1 N mL NaoH/100 gm cheese) at day zero to (15.15±0.71 0.1 N mL NaoH/100 gm cheese) at day 90. The ash content of the cheese was not significantly (P>0.05) affected by the storage period it was increased from (3.74±0.09 %) at the day zero to (5.36±0.19 %) at the day 90 (Table 9).

4.1.7. Effect of storage period on vitamin C and minerals contents of the Sudanese white soft cheese:

Results in table 10 show the main effect of storage period on the vitamin C and minerals contents of the white soft cheese. All the characteristics under investigation (vitamin C, Ca, P, Na and K) were significantly (P<0.05) affected by the storage period and it decreased with the advancement of the storage period. Vitamin C content was decreased from (5.13±0.24 Mg/L) at day zero to (2.31±0.12 Mg/L) at day 90 (Table 10).

Calcium contents of the cheese samples decreased from (11.92±0.20 Mg/L) at day zero to (8.59±0.25Mg/L) at day 90 of storage period.

Phosphorous (P) content of cow's milk cheese was significantly ($P<0.05$) decreased from (6.48±0.16 Mg/L) at day zero to (3.62±1.17 Mg/L) at day 90 of the storage period (Table 10).

Results showed that sodium content of the cheese samples decreased significantly ($P<0.05$) from (53.91±0.51 Mg/L) at day zero to (50.41±0.20 Mg/L) at day 90 (Table 10).

It was clear from (Table 10) that potassium (K) contents of the cheese decreased significantly ($P<0.05$) from (9.83±0.10 Mg/L) at day zero to (6.41±0.82 Mg/L) at day 90.

Table 8: Effect of different levels of cassava powder on sensory characteristics of the Sudanese white soft cheese:

Treatments	Sensory characteristics					
	Color %	**Flavor %**	**Texture %**	**Taste %**	**Saltines %**	**Overall acceptance %**
Control	6.90±2.01 [a]	5.88±2.53	6.56±2.07 [a]	6.41±2.20	5.24±2.42 [d]	6.46±2.00
Cw1	6.65±1.86 [b]	6.30±2.15	5.85±1.63 [c]	6.05±2.35	6.85±1.66 [a]	6.15±2.26
Cw2	6.55±2.15 [c]	5.90±1.86	5.55±1.75 [d]	5.40±2.13	6.15±2.17 [b]	5.80±2.07
Cw3	5.05±2.41 [d]	6.23±1.93	6.03±1.94 [b]	5.56±2.20	5.72±2.41 [c]	5.54±2.09
L.S	***	NS	*	NS	**	NS

Mean values bearing different superscripts within rows are significantly different (P<0.05)
L.S= Levels of significance
Control = Cheese without cassava powder
Cw1=Cheese with 0.5 % cassava
Cw2= Cheese with 0.75 % cassava
Cw3=Cheese with 1 % cassava
NS= Not significance

Table 9: Effect of storage period on physicochemical characteristics of the Sudanese white soft cheese:

Storage period	Physicochemical characteristics of the cheese						
	Total solids %	**Fat %**	**Crude protein %**	**Acidity %**	**pH %**	**VFA(0.1 N mL**	**Ash %**

						NaoH/100 gms cheese)	
Day Zero	41.98±0.88 [d]	21.00±0.54 [b]	21.36±0.49 [b]	0.41±0.01 [d]	4.21±0.08 [a]	6.33±1.58 [a]	3.74±0.09
Day 30	52.73±1.03 [c]	23.29±0.26 [a]	23.27±0.53 [a]	0.81±0.04 [c]	3.68±0.13 [b]	7.95±1.48 [b]	4.14±0.49
Day 60	59.89±0.66 [b]	20.39±0.35 [c]	15.36±0.49 [c]	1.14±0.02 [b]	3.26±0.10 [c]	9.77±1.54 [c]	4.75±0.11
Day 90	65.65±1.35 [a]	18.57±0.62 [d]	11.23±1.39 [d]	1.36±0.02 [a]	2.71±0.10 [d]	15.15±0.71 [d]	5.36±0.19
L.S	***	***	***	***	***	***	NS

Mean values bearing different superscripts within rows are significantly different (P<0.05)
L.S= Levels of significance
NS= Not Significance

Table 10: Effect of the Storage period on vitamin C and minerals contents of the Sudanese white soft cheese:

Storage period	Vitamin C and minerals contents of the cheese				
	Vitamin C mg/L	Ca mg/L	P mg/L	Na mg/L	K mg/L
Day Zero	5.13±0.24 [a]	11.92±0.20 [a]	6.48±0.16 [a]	53.91±0.51 [a]	9.83±0.10 [a]
Day 30	3.69±0.29 [b]	10.86±0.19 [b]	5.21±0.63 [b]	53.38±0.45 [b]	8.58±0.12 [b]
Day 60	2.91±0.05 [c]	9.46±0.27 [c]	4.42±1.19 [c]	51.51±0.13 [c]	7.31±0.10 [c]

Day 90	2.31±0.12 [d]	8.59±0.25 [d]	3.62±1.17 [d]	50.41±0.20 [d]	6.41±0.82 [d]
L.S	***	***	***	***	***

Mean values bearing different superscripts within rows are significantly different (P<0.05)
L.S= Levels of significance

4.1.8. Effect of the storage period on microbiological characteristics of the Sudanese white soft cheese:

Results in (Table 11) showed the main effect of storage period on the microbiological quality of the cow's white soft cheese. All the characteristics under investigation; total viable bacteria, lactobacilli, streptococci, yeasts and moulds, coliforms and *Staphylococcus aureus* counts were significantly ($p<0.05$) affected by the storage period.

Total viable bacteria count of the cheese was significantly ($P<0.05$) increased from log (6.51±0.35 cfu/gm) at day zero to log (7.93±0.06 cfu/gm) at day 60 and then deceased to log (6.58±0.41 cfu/gm) at day 90 of storage.

Lactobacilli count of the cow's milk cheese was significantly ($P<0.05$) decreased from log (5.00±0.40 cfu/gm) at day zero to log (3.34±0.33 cfu/gm) at day 90 of the storage.

Streptococci count in the cheeses samples was significantly ($P<0.05$) decreased from log (5.00±0.36 cfu/gm) at day zero to log (2.65±0.09 cfu/gm) at day 90.

It was observed from (Table 11) that yeasts and moulds of the cheese were significantly ($P<0.05$) increased from log (4.76±0.07 cfu/gm) at day zero to log (6.66±0.09 cfu/gm) at day 90.

It was clear in (Table 11) the coliforms of the cheese decreased significantly ($P<0.05$) from log (5.00±0.15 cfu/gm) at day zero to log (2.29±0.06 cfu/gm) at day 60 and it was not detected at day 90 of the storage.

The results in (Table 11**)** presented that the *Staphylococcus aureus* of the cow's milk cheese was affected significantly ($P<0.05$) by the storage period. It was decreased from log (4.83±0.05 cfu/gm) at day zero to log (3.84±0.08 cfu/gm) at day 90 of the storage.

4.1.9. Effect of storage period on sensory characteristics of the Sudanese white soft cheese:

Results in table 12 showed the main effect of storage period on sensory characteristics of the cheese.

Results revealed that the best values for color, flavor, texture, taste and over all acceptability were obtained at the first day , while the best value for saltiness was recorded at day 30 (Table 12).The color of the cheese was affected significantly ($P<0.5$) by the storage period. The color decreased from day zero up to the end of the storage (day 90). The highest value for the color (7.35±1.81%) was recorded at day zero, while the lowest one (5.10±2.07%) was recorded at day 90.

The flavor of the chesses was significantly ($P<0.05$) affected by the storage period. The flavor scores decreased from day zero up to day 60 and then increased at day 90. The highest value (7.10±1.69) for the flavor was at day zero, while the lowest one (4.85±2.09%) was recorded at day 60 (Table 12).

The texture of the cheese was significantly ($P<0.05$) affected by the storage period. The best value for the texture (6.65±1.56%) was scored at day zero, while the lowest score (5.50±2.06) were scored at day 30 (Table 12).

Saltiness of the cheese was significantly ($p<0.5$) affected by the storage period .The saltiness increased at day 30 and thereafter decreased up to the end of the storage period. The highest saltiness (7.05±2.10%) was found at day30 while the lowest one (5.20±1.96%) was at day 90 (Table 12).

Table 11: Effect of the storage period on microbiological quality of the Sudanese white soft cheese (log cfu/gm):

Storage period	Microbiological quality of the cheese					
	Total viable bacteria (cfu/gm)	**Lactobacilli (cfu/gm)**	**Streptococci (cfu/gm)**	**Yeasts and moulds(cfu/gm)**	**Coliforms (cfu/gm)**	***Staphylococcus aureus* (cfu/gm)**
Day Zero	6.51±0.35 [d]	5.00±0.40 [a]	5.00±0.36 [a]	4.76±0.07 [d]	5.00±0.15 [a]	4.83±0.05 [a]
Day 30	7.61±0.45 [b]	4.09±0.34 [b]	3.99±4.49 [b]	5.13±0.34 [c]	3.31±0.06 [b]	4.77±0.05 [b]
Day 60	7.93±0.06 [a]	3.71±0.13 [c]	3.81±0.31 [c]	5.83±0.12 [b]	2.29±0.06 [c]	4.63±0.05 [c]
Day 90	6.58±0.41 [c]	3.34±0.33 [d]	2.65±0.09 [d]	6.66±0.09 [a]	ND	3.84±0.08 [d]
L.S	***	***	***	***	***	***

Mean values bearing different superscripts within rows are significantly different (P<0.05)
L.S= Levels of significance
Cfu= Colony forming units
ND= Not detected

Table 12: Effect of storage period on sensory characteristics of the Sudanese white soft cheese:

Storage period	Sensory characteristics of the cheese					
	Color %	**Flavor %**	**Texture %**	**Taste %**	**Saltiness %**	**Overall acceptance %**
Day Zero	7.35±1.81 [a]	7.10±1.69 [a]	6.65±1.56 [a]	6.85±1.78 [a]	6.15±2.48 [b]	7.25±1.64 [a]
Day 30	6.45±1.81 [b]	6.00±2.31 [c]	5.50±2.06 [d]	5.10±2.48 [d]	7.05±2.10 [a]	5.25±2.32 [d]
Day 60	6.30±2.54 [c]	4.85±2.09 [d]	6.15±1.86 [b]	5.45±2.66 [c]	5.55±2.02 [c]	5.45±1.89 [c]
Day 90	5.10±2.07 [d]	6.35±1.78 [b]	5.70±1.84 [c]	6.05±1.50 [b]	5.20±1.96 [d]	6.03±2.02 [b]
L.S	***	***	*	**	**	***

Mean values bearing different superscripts within rows are significantly different (P<0.05)

L.S= Levels of significance

According to results obtained in (Table 12) there was significant (P<0.05) effect of the storage period on the over all acceptability of the cheese samples. The over all acceptability decreased by the storage period from day zero up to day 60 and then increased again at day 90. The best over all acceptability (7.25±1.64) was recorded at day zero while the lowest one (5.25±2.32) was in day 30.

4.1.10. Effect of different levels of cassava powder and storage period on physicochemical characteristics of the Sudanese white soft cheese:

Total solids contents of the cheese samples was significantly (P<0.5) affected by the levels of cassava powder and storage period. It was observed that the total solids content decreased with the cassava powder concentration. As the storage period progressed the total solids content increased in value. The highest value (67.38±0.35%) was for the control cheese at day 90 while the lowest one (40.85±0.19) was for the cheese made with 1 % cassava (Table 13).

Results in table 14 showed that fat content was significantly (P<0.5) affected by the levels of cassava powder and storage period it increased with the levels of cassava powder and decreased as the storage period advanced. The lowest fat content (17.92±0.21%) was recorded at day zero in the cheese made without cassava, and the highest one (23.53±0.15%) was found at day 30 in the cheese made from 1 % cassava.

The protein content was significantly (P<0.5) affected by the levels of cassava powder and storage period, it increased with the levels of cassava and decreased with the storage period. The lowest protein content (9.83±0.29%) was observed at day 90 in the cheese without cassava powder, while the highest one (23.68±0.19%) was reported at day 30 in the cheese made from 1 % cassava (Table 15).

Table 13: Effect of different levels of cassava powder and storage period on total solids content (%) of the Sudanese white soft cheese:

Storage period in days	Cassava levels			
	Zero %	0.5 %	0.75 %	1%
Day Zero	43.05±0.84	42.38±0.17	41.63±0.16	40.85±0.19
Day 30	54.00±0.24	53.27±0.64	52.00±0.31	51.56±0.10
Day 60	60.82±0.10	59.28±0.08	60.00±0.38	59.47±0.38
Day 90	67.38±0.35	66.10±0.11	65.27±0.10	63.85±0.60
Level of significance	***			

Table 14: Effect of different levels of cassava powder and storage period on fat content (%) of the Sudanese white soft cheese:

Storage period in days	Cassava levels			
	Zero %	0.5 %	0.75 %	1%
Day Zero	20.13±0.12	21.12±0.12	21.28±0.10	21.45±0.16
Day 30	22.95±0.24	23.33±0.12	23.33±0.05	23.53±0.15
Day 60	20.00±0.17	20.30±0.21	20.47±0.30	20.80±0.09
Day 90	17.92±0.21	18.33±0.22	18.70±0.34	19.32±0.52
Level of significance	***			

Table 15: Effect of different levels of cassava powder and storage period on crude protein content (%) of the Sudanese white soft cheese:

Storage period in days	Cassava levels			
	Zero %	0.5 %	0.75 %	1%
Day Zero	20.60±0.11	21.43±0.26	21.67±0.15	21.73±0.12
Day 30	22.43±0.15	23.50±0.09	23.45±0.25	23.68±0.19
Day 60	14.73±0.21	15.97±0.20	15.40±0.28	15.35±0.16
Day 90	9.83±0.29	10.48±0.32	11.23±0.19	13.38±0.32
Level of significance	***			

The acidity content of the cheese samples (Table 16) was significantly (P<0.5) affected by the levels of cassava powder and storage period. It's increased with both the levels of cassava and storage period. The acidity was the same for the cheese samples with different levels of cassava (0.5, 0.75 and 1%) at day zero. The lowest acidity (0.40±0.01 %) was recorded at day zero in the cheese made without cassava, while the highest one (1.37±0.01%) was at day 90 in the cheese made of 0.75 and 1 % cassava powder.

Data in table 17 shows the pH content of the cheese samples which was significantly (P<0.5) affected by the levels of cassava powder and storage period, it increased with the levels of cassava and decreased with the extended storage period. The lowest pH (2.67±0.08) was reported at day 90 in the cheese made with 0.75% cassava powder, while the highest one (4.23±0.10) was found at day zero in the cheese made of 0.5 % cassava powder.

Results of the volatile fatty acid content of the cheese samples (Table 18) shows that it was significantly (P<0.5) affected by the levels of cassava powder and storage period. It's increased with the increased levels of cassava and storage period. The lowest volatile fatty acid 3.75±0.12 (0.1N ml NaoH/100 gm cheese**)** was at day zero in the cheese made without cassava, while the highest one 15.73±0.12 (0.1N ml NaoH/100 gm cheese) was at day 90 in cheese made from milk with 0.5 % cassava.

Results in table 19 explained that the ash contents was not significantly (P>0.5) affected by the levels of cassava and storage period, slight increase of ash contents with advancement of storage period was observed , while with the levels of cassava no much variations were observed. The lowest ash content (3.70±0.09 %) was recorded at day zero in the cheese made of 0.5 % cassava and the highest one (5.52±0.18 %) was recorded at day 90 in the cheese made of 1 % cassava powder.

Table 16: Effect of different levels of cassava powder and storage period on acidity content (%) of the Sudanese white soft cheese:

Storage period in days	Cassava levels			
	Zero %	0.5 %	0.75 %	1%
Day Zero	0.40±0.01	0.41±0.01	0.41±0.01	0.41±0.01
Day 30	0.78±0.01	0.78±0.05	0.84±0.03	0.82±0.24
Day 60	1.13±0.02	1.15±0.02	1.14±0.02	1.14±0.02
Day 90	1.34±0.01	1.34±0.02	1.37±0.01	1.37±0.01
Level of significance	***			

Table 17: Effect of different levels of cassava powder and storage period on pH content of the Sudanese white soft cheese:

Storage period in days	Cassava levels			
	Zero %	0.5 %	0.75 %	1%
Day Zero	4.20±0.00	4.23±0.10	4.23±0.05	4.17±0.10
Day 30	3.82±0.08	3.62±0.08	3.72±0.10	3.57±0.08
Day 60	3.20±0.09	3.28±0.12	3.28±0.10	3.28±0.08
Day 90	2.72±0.10	2.77±0.12	2.67±0.08	2.70±0.09
Level of significance	**			

Table 18: Effect of different levels of cassava powder and storage period on total volatile fatty acid (0.1N mL NaoH/100 gm cheese) content of the Sudanese white soft cheese:

Storage period in days	Cassava levels			
	Zero %	0.5 %	0.75 %	1%
Day Zero	3.75±0.12	6.68±0.08	7.05±0.18	7.82±0.08
Day 30	5.55±0.19	8.28±0.15	8.57±0.12	9.40±0.09
Day 60	7.50±0.24	9.55±0.10	10.43±0.18	11.58±0.19
Day 90	14.02±0.17	15.73±0.12	15.43±0.21	15.42±0.12
Level of significance	***			

4.1.11. Effect of different levels of cassava and storage period on vitamin C and minerals contents of the Sudanese white soft cheese:

Table 20 presented the vitamin C content of the cheese, it's very clear that vitamin C was significantly ($P<0.5$) affected by the levels of cassava powder and storage period, its increased with the levels of cassava and decreased during the storage period.

The lowest vitamin C (2.13±0.01 mg/L) was reported at day 90 of the storage period in the cheese made without cassava, while the highest one (5.25±0.05 mg/L) was at day zero in the cheese made of 0.75 % cassava powder.

Calcium content was significantly (P<0.5) affected by the levels of cassava powder and storage period it's increased with the levels of cassava and decreased with the storage period. The lowest calcium (8.37±0.23 mg/L) was recorded at the day 90 of the storage period in the cheese made without cassava, while the highest one (12.13±0.06 mg/L) was noticed at day zero in cheese made of 1 % cassava powder (Table 21).

Results in table 22 is the phosphorous content of the cheese samples, it's clearly showed that phosphorous content was significantly (P<0.5) affected by the levels of cassava powder and storage period. It's increased with the levels of cassava and decreased with storage time. The lowest phosphorus (3.43±0.02 mg/L) was recorded at day 90 of the storage period in the cheese made of 1 % cassava, while the highest one (6.70±0.04 mg/L) was at day zero in the same cheese sample.

It was noticed from the results recorded in table 23 that the sodium content was not significantly (P>0.5) affected by the levels of cassava powder and storage period. It was increased with the levels of cassava and decreased with the storage.

Table 19: Effect of different levels of cassava powder and storage time on ash content (%) of the Sudanese white soft cheese:

Storage period in days	Cassava levels			
	Zero %	0.5 %	0.75 %	1%
Day Zero	3.78±0.08	3.70±0.09	3.75±1.38	3.73±0.05
Day 30	4.43±0.05	4.30±0.11	4.37±0.12	4.38±0.14
Day 60	4.72±0.10	4.63±0.05	4.80±0.06	4.83±0.08
Day 90	5.18±0.17	5.32±0.08	5.42±0.16	5.52±0.18
Level of significance	NS			

Table 20: Effect of different levels of cassava powder and storage period on vitamin C content (mg/L) of the Sudanese white soft cheese:

Storage period in days	Cassava levels			
	Zero %	0.5 %	0.75 %	1%
Day Zero	4.80±0.28	5.24±0.03	5.25±0.05	5.24±0.03
Day 30	3.20±0.02	3.82±0.01	3.86±0.01	3.87±0.01
Day 60	2.84±0.04	2.91±0.01	2.95±0.01	2.94±0.02
Day 90	2.13±0.01	2.35±0.02	2.35±0.78	2.42±0.04
Level of significance	***			

Table 21: Effect of different levels of cassava powder and storage period on calcium content (mg/L) of the Sudanese white soft cheese:

Storage period in days	Cassava levels			
	Zero %	0.5 %	0.75 %	1%
Day Zero	11.70±0.21	11.87±0.12	11.97±0.13	12.13±0.06
Day 30	10.66±0.28	10.82±0.10	10.90±0.06	11.06±0.09
Day 60	9.20±0.03	9.32±0.05	9.45±0.06	9.89±0.07
Day 90	8.37±0.23	8.38±0.04	8.81±0.04	8.82±0.06
Level of significance	***			

Table 22: Effect of different levels of cassava powder and storage period on phosphorous content (mg/L) of the Sudanese white soft cheese:

Storage period in days	Cassava levels			
	Zero %	0.5 %	0.75 %	1%
Day Zero	6.29±0.04	6.43±0.10	6.51±0.08	6.70±0.04
Day 30	5.18±0.05	4.81±1.23	5.39±0.07	5.47±0.05
Day 60	4.21±0.04	4.34±0.03	4.45±0.04	4.67±0.15
Day 90	3.85±0.04	3.69±0.03	3.51±0.04	3.43±0.02
Level of significance	**			

The lowest sodium (50.04±0.02 mg/L) was at day 90 of the storage period in the cheese made with 1 % cassava, while the highest one (54.37±0.10 mg/L) was recorded at day zero in the same sample (1 % cassava) (Table 23).

Potassium content was not significantly (P>0.5) affected by the levels of cassava powder and storage period, its increased with the levels of cassava up to

day 60 and then decreased at day 90 with addition of cassava. The lowest Potassium (6.07±0.02 mg/L) was reported at day 90 of the storage period in the cheese made with 1 % cassava, while the highest one (9.96±0.04 mg/L) was at day zero in the same sample (1 % cassava) (Table 24).

4.1.12. Effect of different levels of cassava and storage period on microbiological characteristics of the Sudanese white soft cheese:

Results in table 25 indicated that total bacteria count was significantly (P<0.5) affected by the levels of cassava powder and storage period it was increased with the levels of cassava from day zero up to day 60 of the storage period, its also increased with the storage period from day zero up to day 60 and then decreased at day 90. The total bacteria count was higher in the cheese samples made from cassava powder compared with that made without cassava. The lowest total bacteria count (5.90±0.03 log cfu/gm) was recorded at day 90 of the storage period in the cheese made without cassava , while the highest one (7.97±0.01 log cfu/gm) was at day 60 in the cheese sample made of 1 % cassava powder.

Lactobacilli count was significantly (P<0.5) affected by the levels of cassava powder and storage period (Table 26) , its decreased with the addition of cassava powder from day zero up to day 60 and then increased at day 90 of the storage. It was also decreased with storage period from day zero up to the end in all samples.

Table 23: Effect of different levels of cassava powder and storage period on sodium content (mg/L) of the Sudanese white soft cheese:

Storage period in days	Cassava levels			
	Zero %	0.5 %	0.75 %	1%
Day Zero	53.10±0.08	54.06±0.12	54.12±0.21	54.37±0.10
Day 30	52.93±0.04	53.60±0.35	53.08±0.06	53.94±0.03
Day 60	51.31±0.04	51.49±0.04	51.57±0.04	51.66±0.03
Day 90	50.77±0.05	50.55±0.06	50.11±0.02	50.04±0.02
Level of significance	NS			

Table 24: Effect of different levels of cassava powder and storage period on potassium content (mg/L) of the Sudanese white soft cheese:

Storage period in days	Cassava levels			
	Zero %	0.5 %	0.75 %	1%
Day Zero	9.71±0.05	9.77±0.04	9.87±0.05	9.96±0.04
Day 30	8.44±0.03	8.54±0.02	8.65±0.04	8.70±0.11
Day 60	7.19±0.06	7.31±0.04	7.33±0.03	7.43±0.02
Day 90	6.77±0.05	6.17±0.05	6.10±0.02	6.07±0.02
Level of significance	NS			

Table 25: Effect of different levels of cassava powder and storage period on total viable bacteria count (Log cfu/gm) of the Sudanese white soft cheese:

Storage period in days	Cassava levels			
	Zero %	0.5 %	0.75 %	1%
Day Zero	5.92±0.07	6.78±0.12	6.67±0.02	6.67±0.01
Day 30	6.85±0.05	7.84±0.04	7.87±0.01	7.86±0.01
Day 60	7.84±0.07	7.96±0.02	7.95±0.02	7.97±0.01
Day 90	5.90±0.03	6.81±0.01	6.81±0.00	6.83±0.03
Level of significance	***			

Table 26: Effect of different levels of cassava powder and storage period on lactobacilli (Log cfu/gm) of Sudanese white soft cheese:

Storage period in days	Cassava levels			
	Zero %	0.5 %	0.75 %	1%
Day Zero	5.68±0.04	4.78±0.09	4.79±0.02	4.77±0.12
Day 30	4.66±0.14	3.92±0.05	3.92±0.01	3.87±0.01
Day 60	3.88±0.03	3.69±0.05	3.57±0.08	3.65±0.08
Day 90	2.78±0.08	3.51±0.02	3.53±0.03	3.54±0.04
Levels of significance	***			

The lowest lactobacilli count (2.78±0.08 log cfu/gm) was recorded at day 90 of storage in the cheese made without cassava, while the highest one (5.68±0.04 log cfu/gm) was at day zero in the same cheese sample.

Its very clear from the results in table 27 the streptococci count significantly ($P<0.5$) affected by the levels of cassava powder and storage period , its

decreased with the addition of cassava powder from day zero up to day 60 and then increased with an increased of cassava powder. The lowest streptococci count (2.51±0.02 log cfu/gm) was recorded at day 90 of the storage in the cheese made without cassava , while the highest one (5.59±0.09 log cfu/gm) was recorded at day zero in the same cheese sample.

Yeasts and moulds count significantly (P<0.5) affected by levels of cassava powder and storage period , its decreased with the levels of cassava in the most samples from day zero up to day 60 and then increased , its also increased with the storage period from day zero up to the end in all samples (Table 28). The lowest yeasts and moulds count (4.71±0.06 log cfu/gm) were recorded at day zero of storage in the cheese made with 0.75 % cassava, while the highest one (6.73±0.05 log cfu/gm) was reported at day 90 in cheese sample made from 1% cassava.

Coliforms count significantly (P<0.5) affected by the levels of cassava powder and storage period (Table 29). The coliforms count increased with addition of cassava at day zero and then decreased in most of the samples at day 30 and 60 of the storage period and completely disappeared at day 90. It's also decreased with the storage period from day zero up to day 60 and totally dispread at the end of the storage.

Table 27: Effect of different levels of cassava powder and storage period on streptococci count (Log cfu/gm) of the Sudanese white soft cheese:

Storage period in days	Cassava levels			
	Zero %	0.5 %	0.75 %	1%
Day Zero	5.59±0.09	4.77±0.05	4.80±0.05	4.84±0.03
Day 30	4.81±0.05	3.76±0.05	3.65±0.05	3.73±0.02
Day 60	4.17±0.04	3.36±0.13	3.86±0.07	3.85±0.07
Day 90	2.51±0.02	2.64±0.05	2.72±0.01	2.73±0.02
Levels of significance	***			

Table 28: Effect of different levels of cassava powder and storage period on yeasts and moulds count (Log cfu/gm) of the Sudanese white soft cheese:

Storage period in days	Cassava levels			
	Zero %	0.5 %	0.75 %	1%
Day Zero	4.77±0.05	4.74±0.06	4.71±0.06	4.85±0.03
Day 30	5.70±0.14	4.95±0.03	4.90±0.02	4.97±0.00
Day 60	5.95±0.02	5.65±0.08	5.87±0.05	5.84±0.02
Day 90	6.57±0.11	6.65±0.07	6.70±0.04	6.73±0.05
Levels of significance	***			

Table 29: Effect of different levels of cassava powder and storage period on coliforms count (log cfu/gm) of the Sudanese white soft cheese:

Storage period in days	Cassava levels			
	Zero %	0.5 %	0.75 %	1%
Day Zero	4.77±0.11	5.05±0.02	5.08±0.04	5.10±0.03
Day 30	3.41±0.03	3.29±0.02	3.27±0.04	3.29±0.04
Day 60	2.37±0.02	2.27±0.02	2.26±0.02	2.26±0.04
Day 90	ND	ND	ND	ND
Levels of significance	***			

ND= Not detected

Table 30: Effect of different levels of cassava powder and storage period on *Staphylococcus aureus* count (log cfu/gm) of the Sudanese white soft cheese:

Storage period in pays	Cassava levels			
	Zero %	0.5 %	0.75 %	1%
Day Zero	4.90±0.01	4.80±0.01	4.81±0.01	4.83±0.03
Day 30	4.81±0.03	4.73±0.01	4.77±0.07	4.78±0.06
Day 60	4.64±0.01	4.58±0.07	4.66±0.01	4.66±0.01
Day 90	3.82±0.07	3.92±0.07	3.77±0.05	3.85±0.03
Levels of significance	***			

In table 30 *Staphylococcus aureus* count significantly (P<0.5) affected by the levels of cassava powder and storage period. The control cheese recorded the highest *Staphylococcus aureus* count compared with that made from different levels of cassava and it increased with the levels of cassava and decreased with storage. The lowest *Staphylococcus aureus* (3.77±0.05 log cfu/gm) was

recorded at day 90 in the cheese made with 0.75 % cassava, while the highest one (4.90±0.01 log cfu/gm) was at day zero in the control cheese.

4.1.13. Effect of different levels of cassava powder and storage period on sensory characteristics of the Sudanese white soft cheese:

Color of the cheese was not significantly (P>0.5) affected by the different levels of cassava and storage period. Color of the cheese decreased with the addition of cassava (Table 31). Color of the control and 0.5 % cassava decreased in the day 30 of the storage and increased at the day 60 and decreased again at the end of the storage while in the samples made from 0.75 and 1% cassava it decreased with the storage period. The best color (7.91±1.38 %) was obtained at day zero from control cheese and the worst one (3.60±1.65 %) was obtained at day 90 in cheese made from 1 % cassava.

Table 31: Effect of different levels of cassava powder and storage period on color (%) of the Sudanese white soft cheese:

Storage period in days	Cassava levels			
	Zero %	0.5 %	0.75 %	1%
Day Zero	7.91±1.38	7.60±1.65	7.40±2.15	6.33±2.00
Day 30	6.80±1.48	6.60±1.58	6.60±2.27	5.80±1.93
Day 60	7.60±1.91	7.00±1.89	6.00±2.36	4.60±3.11
Day 90	5.20±2.20	5.40±1.84	6.00±1.93	3.60±1.65
Levels of significance	NS			

Table 32: Effect of different levels of cassava powder and storage period on flavor (%) of the Sudanese white soft cheese:

Storage period in days	Cassava levels			
	Zero %	0.5 %	0.75 %	1%
Day Zero	7.55±1.57	7.20±1.48	7.00±1.89	6.56±1.94
Day 30	5.20±2.91	6.60±1.58	5.80±2.35	6.40±2.32
Day 60	3.80±2.32	5.60±2.81	6.84±0.84	5.40±1.57
Day 90	6.80±1.48	5.80±2.35	6.20±1.41	6.60±1.84
Levels of significance	NS			

Flavor of the cheese was not significantly (P>0.5) affected by the different levels of cassava and storage period, it's decreased in the most samples with addition of cassava and storage period. The best flavor (7.55±1.57 %) was obtained at day zero from control cheese, while the worst one (3.80±2.32 %) was obtained at day 60 in the same sample. Cheese made without cassava obtains the highest values for flavor compared with that made from 0.5, 0.75 and 1 % respectively (Table 32).

In table 33 texture of the cheese significantly (P<0.5) affected by the different levels of cassava and storage period. The control cheese obtained the highest value for texture compared with that made from 0.5, 0.75 and 1% cassava respectively. The highest texture (7.73±1.62 %) was obtained at day zero from control cheese, while the worst one (4.60±1.58 %) was obtained at day 60 in cheese made from 0.75 % cassava.

Taste of cheese was not significantly (P>0.5) affected by the different levels of cassava and storage period. Taste decreased with the addition of cassava in the most samples. Taste of cheese made from 1 % cassava decreased with the storage period from day zero up to the end. The highest scores for taste (7.55±1.57 %) was obtained at the day zero from control cheese, while the worst one (4.00±2.36 %) was obtained at day 30 in the cheese made from 0.75 % cassava. Control cheese obtains highest values for taste (Table 34).

Saltiness decreased with the addition of cassava powder. Cheese made from 0.5 % cassava obtains the highest saltiness compared with that made without cassava, 0.75 and 1 % respectively (Table 35).

Table 33: Effect of different levels of cassava powder and storage period on texture (%) of the Sudanese white soft cheese:

Storage period in days	Cassava levels			
	Zero %	0.5 %	0.75 %	1%

Day Zero	7.73±1.62	5.60±1.35	6.40±.1.10	6.78±1.56
Day 30	6.20±1.69	6.20±1.93	5.00±2.11	4.60±2.27
Day 60	6.40±2.12	6.20±1.03	4.60±1.58	7.40±1.58
Day 90	5.80±2.53	5.40±2.07	6.20±1.69	5.40±0.84
Level of significance	*			

Table 34: Effect of different levels of cassava powder and storage period on taste (%) of the Sudanese white soft cheese:

Storage period in days	Cassava levels			
	Zero %	0.5 %	0.75 %	1%
Day Zero	7.55±1.57	6.60±1.84	6.60±1.84	6.56±1.94
Day 30	6.00±1.94	6.00±3.11	4.00±2.36	4.40±2.12
Day 60	5.60±3.27	5.60±2.84	4.80±2.02	5.80±2.71
Day 90	6.40±1.35	6.00±1.72	6.20±1.41	5.60±1.65
Level of significance	NS			

Table 35: Effect of different levels of cassava powder and storage period on saltiness (%) of the Sudanese white soft cheese:

Storage period in days	Cassava levels			
	Zero %	0.5 %	0.75 %	1%
Day Zero	6.27±2.57	6.80±2.39	6.20±1.93	5.22±3.07
Day 30	6.00±2.36	7.80±1.41	7.40±2.27	7.00±2.11
Day 60	3.80±1.41	6.40±0.97	6.20±1.93	5.80±2.53
Day 90	4.80±2.57	6.40±1.35	4.80±2.01	4.80±1.48
Level of significance	NS			

Table 36: Effect of different levels of cassava powder and storage period on over all acceptability (%) of the Sudanese white soft cheese:

Storage period in days	Cassava levels			
	Zero %	0.5 %	0.75 %	1%
Day Zero	8.10±1.04	7.40±1.84	6.80±1.48	6.56±1.94
Day 30	5.60±2.32	5.20±2.09	4.60±2.46	5.60±2.67
Day 60	5.20±1.75	6.40±2.50	5.40±1.58	4.80±1.48
Day 90	6.80±1.48	5.60±2.32	6.40±2.12	5.30±2.00
Level of significance	NS			

The highest saltiness (7.80±1.41 %) was obtained at day 30 of storage in cheese made from 0.5 % cassava while the lowest one (3.80±1.41%) was obtained at day 60 in cheese made without cassava.

In table 36 over all acceptability decreased with addition of cassava powder in most samples. In general cheese made without cassava recorded higher over all acceptability flowed by that made with 0.5 % cassava. The highest over all acceptability (8.10±1.04 %) obtained at day zero in control cheese, while the lowest one (4.60±2.46 %) was obtained at day 30 in cheese made from 0.75 % cassava.

4.1.14. Effect of different levels of cassava powder on yield of the Sudanese white soft cheese:

According to the results in table 37 yield of the Sudanese white soft cheese was affected by the addition of different levels of cassava powder; it's increased with the addition of cassava powder. The cheese made with 1 % cassava powder obtained the highest yield, followed by the one made from 0.75 % and 0.5 % respectively, while the lowest yield was recorded by the cheese made from milk without cassava.

Table 37: Effect of different levels of cassava powder on yield of the Sudanese white soft cheese:

Treatments	**Control**	**Cw1**	**Cw2**	**Cw3**
Yield of the cheese %	15.93 %	16.85 %	17.41 %	17.78 %

Control = Cheese without cassava powder
Cw1=Cheese with 0.5 % cassava powder
Cw2= Cheese with 0.75 % cassava powder
Cw3=Cheese with 1 % cassava powder

Chapter Five

Discussion

5. 1. Effect of different levels of cassava powder on the physicochemical characteristics of the Sudanese white soft cheese:

Total solids of the cheese samples decreased with the increasing levels of cassava powder (Table 5). This could be attributed to the high moisture content in the cheese made from different levels of cassava. These results were in line with those reported by Biradar *et al*.(2012) who studied the effect of different levels of soybean milk (10 , 20 , 40 and 50 %) on the chemical composition of cheese made from buffalo milk and found that total solids decreased with the levels of soybean milk. These Results were also in agreement with those obtained by Nazim *et al*. (2013) and Rinaldoni *et al*. (2014) who noticed that the total solids content were lower in a cheese made from soybean compared to that made from cow milk. Similar results were also recorded by Billal (2000) who studied the chemical composition of a Sudanese white cheese affected by different levels of soymilk (5,10 and 15 %) and he stated that total solids decreased with the levels of soymilk.

The results obtained were different from those of Ali (2012) who used four different levels of skim milk powder (0 , 3 , 6 and 9 %) in the manufacturing

of labenh cheese and he finally reported that total solids increased with the levels of skim milk powder.

The total solids found in this study were within the range of the total solids given by Nazar *et al.*(2012) who collected 10 samples of a Sudanese white soft .% cheese and reported that its range from 30- 65

Fat content of the cheese samples increased with the increased levels of cassava powder (Table 5). This could be due to the high amount of Ether extract in cassava. These results coincided those of Esmaiel *et al*. (2010) who used three concentration of Arabic Gum (0.25 , 0.05 and 0.75 gram per each kilogram of milk) to manufacture the Iranian low fat white cheese and revealed that fat content increased with the levels of Arabic Gum. Our results were similar to those of Abdel-Razig and Sewayleh (2009) who showed that fat content of labenh cheese increased with the levels of skim milk powder. Oladipo and Jadesimi (2013) Studied the fat content of West African soft cheese made with garlic and concluded that fat was higher in the garlic cheese.

The results of this study contradicted the work of Okorie and Adedokum (2013) who used seven varied levels (5,10,15,20,30,40 and 50 %) of the Bambaranut milk in the manufacturing of the Nigerian Warankashi white soft cheese and realize that fat decreased with the levels of the Bambaranut milk.

Results in table 5 showed that protein increased with the levels of cassava. This increased could be due to the effect of cassava powder and heat treatment which resulted in denaturing of whey protein and their retention in the cheese curd. It could also be due to the high amount of the protein in cassava powder. Similar increased in protein contents was revealed by Rajaj *et al*. (2014) who found that protein increased with the levels of soybean milk. These results were also in line with those obtained by Abdual-Rahaman (2013) who reported that protein percentage was higher in a cheese made with safflower

seed extract. The protein content of the cheese made with cassava in this study were very low compared to that obtained by Fashakin and Unkiwedi (1992) who added melon to milk cheese and found that protein content was about .44.5%

Our results were different from those of Pinar and Mustafa (2011) who mentioned that protein was lower in fresh Kashar cheese of turkey produced from soy protein.

Titratable acidity of the cheese samples was increased with the levels of cassava powder (Table 5). This increased could be explained by that cassava powder may stimulate the growth of lactic acid bacteria present in the raw milk. These results were in agreement with those of Ali (2012) who recorded similar increased in the acidity of Labenh cheese. The same results were notice by Abdel-Razig and Sewayleh (2009) in a labenh cheese made with different levels of skim milk powder.

Our results were also supported by the work of Rajaj *et al*. (2014) who investigated the effect of two different levels of soybean milk (50 and 75 %) on the quality of the Indian Panneer fresh white cheese and recorded that acidity increased with the levels of soybean milk. The values recorded for the acidity in this study were within the range reported by Nazar *et al*.(2012) who noticed the acidity of the Sudanese white soft cheese range between 0.03 to 2.50 % . However, our results were not in line with those reported by Kheir *et al*. (2011) who stated that acidity was lower in a Sudanese white cheese made with *Solanum dubium*.

Results in table 5 showed that volatile fatty acids of the cheese samples increased with the levels of cassava. This could be attributed to fact that adding of cassava powder to milk cheese inhibits some microbial enzymes. The increased of the volatile fatty acid with the levels of cassava could also be due to decreased of the pH values. These results were not far from those

obtained by Adam (2011) who recorded an increased of the volatile fatty acid of cheese made from different levels of black cumin. The same results were demonstrated by Abd Elghaffar (2011) who studied the volatile fatty acid of cheese made from different levels of *Solanum dubium* (Gubin) and he reported that total volatile fatty acid content increased with the concentration of *Solanum dubium*.

The pH of the cheese decreased with the levels of cassava (Table 5). The decreased of the pH could be due to the increased of moisture content or increased of the acidity. These results were in harmony with those of Biradar *et al*. (2012) who reported that pH decreased with the levels of soybean milk. Similar results were obtained by Pinar and Mustafa (2011) who used soy protein in the manufacturing of fresh Kashar cheese of turkey.

Our results contradicted the work of Nazim *et al.* (2013) and Rinaldoni *et al*. (2014) who reported that pH content were higher in a soymilk cheese compared with that made from cow milk. These results have been supported by those of El-Tantawy *et al*.(2006) who studied the physicochemical characteristics of white soft cheese made from Goat's milk supplemented with different levels of clove powder and stated that pH increased with the levels of clove.

Ash content of the cheese samples in this study increased with the levels of cassava powder (Table 5). This could be attributed to the high nutrients and minerals contents of cassava. The increased of the ash content could also be explained by the absorption of salt by curd. Similar increased of ash was reported by Fasakin and Unokiwedi (1992) during the chemical analysis of cheese made with melon milk. Our findings were not far from those given by Naveed *et al.*(2008) who mentioned that ash contents was higher in a soft cheese made with soybeans. The values of the ash found in this study were higher than that reported by Yakubu and Amuzat (2012) who reported that ash contents of Tofu cheese produced in Northern part of Nigeria was about

(3.30±1.82%). These results were not in line with those of Abdual-Rahaman (2013) who reported that ash percentage was lower in a cheese made with safflower seed extract.

Effect of different levels of cassava powder on vitamin C and minerals .2 .5 :of the Sudanese white soft cheese

Results in table 6 indicated that vitamin C increased with the levels of cassava. This could be attributed to the high content of vitamin C which is present in cassava. Coskun (2005) reported that the amount of vitamin C in the Otlu cheese of Turkey were about (3mg/100g of cheese). Nazim *et al* ., (2013) studied the vitamins content of the cheese and reported that B vitamins and vitamin D were higher in the cheese made from soybean compared with that .made with cow milk

Calcium contents in the cheese samples under study were increased as the cassava levels increased (Table 6). This increased of Ca content with cassava levels probably could be attributed to the high content of Ca in cassava. Similar increased were observed by Nazim *et al*.(2013) and Naveed *et al*. (2008) who stated that Ca was higher in a soy cheese compare with cow milk. Calcium content found in this study was higher from that obtained by Farahani *et al*. (2013) in the Iranian white cheese; this could be attributed to high Ca in Cassava powder as mentioned above.

Results in table 6 showed that phosphorus content increased with levels of cassava. Cassava contains a significance amount of phosphorus which might be the reason for the high amount of phosphors in cheese made from different levels of cassava. These results agreed with those of Okorie and Adedokum (2013) who used seven different levels of Bambaranut in the manufacturing of the Nigerian Warankashi soft cheese and they found that P increased with the levels of the Bambaranut milk. These results matched with those of Naveed (2008) who mentioned that P was higher in a soy cheese compare with Cheddar cheese.

Sodium increased with the levels of cassava (Table 6) .This could be attributed to the high Na in cassava. Our results were supported by the results obtained by Nazim *et al*.(2013) who noticed that Na content was higher in a soymilk cheese compared to that made from cow milk.

Table 6 showed that K contents of cheese samples increased slightly in the sample made from 1 % cassava. This increase could be due to fact that cassava contains significance amount of potassium. Similar results were obtained by Mohamed *et al*. (2014) who used three levels of salt concentration to manufacture a Sudanese cheese and stated that K increased with the levels of salt concentration.

Waleed *et al*., (2013) collected 5 samples of a Sudanese white soft cheese produced at small scale level in Al Dueim city and reported that Ca of the cheese range from (398±16.17 to 505±8.66 mg/100g), P range from (91.12±0.15 to108.00±2.31 mg/100g) , Na range from (189±0.79 to 315±0.08 mg/100g) and finally K content of the cheese range from (49.33±1.85 to 79.00±4.04 mg/100g).

On the other hand Gonzalez *et.al*.(2009) studied the minerals contents of the cheese during 6 months of ripening and found that Ca rang from (4.49 to 40.38 g/k) , P range from (3.35 to 6.03 g/k) , Na range from (2.76 to13.92 g/k) and K range from (0.62 to 2.17 g/k) , while Demirci (1988) found the concentrations of Ca, P, Na and K in the Otlu cheese of Turkey were about 678, 416, 1103 and 180 mg/100g of cheese respectively.

5. 3. Effect of different levels of cassava powder on the microbiological quality of the Sudanese white soft cheese:

Results in able 7 showed that total bacteria counts of the cheese samples in this study increased with the levels of cassava powder. Total bacteria of the cheese made from cassava were higher compared with that made from

milk without cassava. This could be attributed to the fact that cassava powder has additional nutritive value which leads to increased of the microbiological load of the cheese made from different levels of cassava. Similar results were recorded by Kheir *et al* .(2011) who used *Solanum dubium* fruit extract to manufacture a Sudanese white soft cheese and he demonstrated that total bacteria counts were higher in the cheese made with Solanum compared to that made with rennet. Our results in this study were not in agreement with those of Alsawaf and Alnaemi (2011) who used two levels of *Nigella sativia* seeds (1 and 3 %) to study some poisoning and pathogenic bacteria of the Sudanese white soft cheese made from ewes milk and he founded that total bacteria count decreased with the levels of Nigella seeds.

Badawi *et al* ., (2009) indicated that total bacteria count decreased with *Nigela sativa* levels , and their results were supported by Al-Neaamy(2008) who indicated that adding of *Nigella sativa* seed at the concentration of 1% to the processed cheese inhibited the microbial growth including the total bacteria .count

Results in table **7** indicated that lactobacilli and Streptococci were both decreased with the levels of cassava. The decreased of lactobacilli and streptococci with the levels of cassava could be attributed to high acidity or the low pH of the cheese made from different levels of cassava. Similar results were obtained by Adam (2011) who used five levels of black cumin seed to manufacture the Sudanese white soft cheese and reported that lactic acid bacteria decreased with the levels of black cumin.

Kheir *et al* ., (2011) used *Solanum dubium* fruit extract in the manufacturing of a Sudanese white soft cheese and he reported that lactobacilli and streptococci were both higher in the cheese made with Solanum compared to that made with rennet.

Yeasts and moulds decreased with the levels of cassava (Table **7**). This could be attributed to some antimicrobial agents in cassava which inhibited the growth of yeasts and moulds. These results agreed with the work of Nour El Diam and El Zubier (2006) who reported that yeast and moulds decreased when they used two different levels of fat (2.2 and 4.4 %) for cheese manufacturing. These results contradicted those of Amer (2008) who used three acidifying agents for the manufacturing of Ricotta cheese and he did not found any yeasts and moulds in the different Ricotta cheese samples.

The results recorded in table **7** indicated that coliforms count increased with the levels of cassava. Coliforms can metabolize the high acidity and low pH of the cheese made from cassava and it can grow normally. Our results were in disagreement with those of Badawi *et al.* (2009) who revealed that coliforms counts decreased with *Nigella sativa* levels. Ali (2012) stated that coliforms were not found in a labenh cheese made from different levels of skim milk powder. Our results were also in disagreement with those of Kamal and Babiker (2009) who did not recorded any coliforms in cheese made with acidifying agents. Availability of coliforms in cheeses emphasized the importance of contamination during cheese making as reported by Coskun (1998) and Hatzikamari *et al*.(1999).

The values recorded for coliforms in this study were higher from that reported by Nazar *et al.* (2012) when he collected 10 samples of a Sudanese white soft cheese and reported that coliforms ranged from 0.0 to 1.00 cfu/gm.

Staphylococcus aureus of the cheese samples decreased with the levels of cassava (Table **7**). This decreased could be due to the low pH of the cheese made from cassava. It could also be attributed to some antimicrobial agents in cassava. The same results were obtained by Sabreen (1996) who showed similar effect of *Nigella Sativa* seed on *Staphylococcus aureus* of Domiati cheese. Our results were in disagreement with those of Kamal and Babiker (2009) who did

not recorded any *Staphylococcus aureus* in a cheese made from three different acidifying agents.

Kosikowaki (1997) reported that cheese made from raw milk , which is drawn by hand or milk drawn from infected udder are usually contaminated with *Staphylococcus aureus*. However Santos and Genigeorgis (1981) stated that post-pasteurization contamination by *Staphylococcus aureus* was due to *Staphylococcus aureus* from human and environmental factors, uncontrolled temperature during handling and condition of the cheese storage. Ahmed (1985) reported that 60 % of the cheese samples collected from Khartoum market was contaminated with *Staphylococcus aureus*.

5. 4. Effect of different levels of cassava on the sensory characteristics of the white soft cheese:

Results in table 8 indicated that cheese made from milk without cassava recorded the highest values for color, texture, taste and overall acceptability, while the best values for flavor and saltines were recorded by the cheese made from 0.5 % cassava. In other words the cheese made from milk without cassava and the one made from milk with the lowest amount (0.5) % recorded the highest values for the sensory characteristics. This could be attributed to properties of cassava which change the sensory characteristics of the cheese specially color, flavor and taste, while most of the consumers (panelist) like the cheese with white color, good flavor and taste which were very clear in the cheese made from milk without cassava.

These results agreed with those of Bilal (2000) who used varied levels of soymilk to manufacture a Sudanese white soft cheese and he demonstrated that sensory characteristics decreased with the levels of soymilk.

These results were not in line with those obtained by Biradar *et al*.
(2012) who stated that sensory characteristics of the Indian panneer fresh white

cheese were improved with the addition of different levels of soybean milk. Our findings were also different from those recorded by Okorie and Adedokum (2013) who reported that sensory characteristics were improved in the cheese made from different levels of Bambaranut milk.

5. 5. Effects of the storage period on the physicochemical characteristics of the Sudanese white soft cheese:

Total solids of the cheese samples increased during the storage period (Table 9). This increased could be attributed to decreased in the moisture content as a result of lactic acid developments which caused curd contraction (Sameen *et al* ., 2008 ; El- Safty *et al* ., 2004 ; Ali and Galal ,2002 ; Celik *et al* .,2002 and El-Koussy *et al* ., 1995). Similar results were obtained by (Abdalla *et al.*, 2011; Abdel-Razig and Babiker, 2009; El-Owni and Hamid, 2008 and Hamid, 2005) who reported that total solids of the Sudanese white soft cheese increased during the storage period. Abd-El-Salam *et al*., (1993) stated that the increased of the total solid could be due to salt absorption and water diffusion of some soluble components between brine and cheese mass.

Our results were different from those of Osman and Nuser (2009) who said that total solids content of a vacuum packaged white cheese decreased with the storage period. Their results have been supported by Nuser (2001) and Haylogalo *et al* .(2005) who stated that total solids decreased during the storage period due to proteolytic and lipolytic effect of microorganisms on proteins and dissolution of fats into pickling solution.

Fat contents of the cheese samples decreased with the storage period (Table 9). The decreased of fat contents could be explained by the degradation of the total fat, dissolution of salt and fat into the pickling solution or absorption of whey by curd (Nasur 2001). Other results demonstrated that the decreased in fat content was probably due to the lipolytic activity of microorganisms on fat

resulting in a leakage of some fat from crude into the pickling whey (Kumar and Jha, 1997; El-Sheikh, 1997; Khalid, 1991 and Abbala, 1992).

These results confirmed the findings of Abdala *et al*.(2011) ; Talib *et al* . (2009); Ayse (2009) and Mian *et al*.(2014) who demonstrated that fat content of the Sudanese white soft cheese decreased with the storage period. Osman and Nuser (2009) said that fat content of the vacuum packaged white cheese decreased with the storage period.

Our results were not in line with those reported by Zekai *et al*.(2004) ; Marhan *et al.(*2000) ; Mohamed and Nusur (2009) and Abdella *et al* (2011) who indicated that fat content increased with the storage period. Farbod *et al.,* (2013) recorded similar increased in the fat content with the storage period in a Feata cheese fortified with fish and olives oil.

Protein contents of the cheese samples in this study decreased with the storage period (Table 9). Nusuer (2001) found that the decreased in the protein contents during pickling was a direct result of protein degradation leading to the formation of water soluble compounds which were lost in the pickling whey. These findings confirmed the work of Billial (2000); Khaild (1991) Abdalla *et al*. (1993) and Abd-El-Salam (1993) who stated that protein contents of the Sudanese white soft cheese decreased during the storage period. Similar results were reported by Osman and Nuser (2009) who said that protein content of vacuum packaged white cheese decreased with the storage period. However the decreased in protein content through out the storage was probably attributed to degradation of protein and its loss in the pickling whey (Zaekai *et al.*, 2004 and Hayalogolou *et al*., 2005).

The total protein found in this study was higher from that obtained by Saeed (2009) this could be attributed to the high levels of crude protein found in cassava powder which was used in the study. However the increased in protein

contents that occurred in day 30 of the storage period could be due to loss of moisture (Kamal and Babiker, 2009).

Our results contradicted those of Mohamed (2011); Zekai *et al. (*2004) and Abdel- Razig and Abdalla (1997) who stated that protein content increased with the storage period. The increased of protein can be explained by the loss of moisture content during the storage period (El-Sheikh , 1997).

Ash contents of the cheese samples in this study increased with the storage period (Table 9). Increased in ash content may be due to the decreased in moisture content and absorption of salt by curd (Abdalla and Abdel Razig, 1997). These results coincided with those obtained by Abdalla *et al*.(2011) ; Elowni and Hamid (2008) and Kamal and Babiker (2009) who found the ash contents of a Sudanese white soft cheese increased during the storage period. Similar results were obtained by Osman and Nuser (2009) who revealed that ash contents of a vacuum packaged white cheese increased with the storage period. Abdalla (1992) attributed the decreased of ash content as a results of diffusion of salt from curd whey.

The pH decreased till the end of the storage period (Table 9). This might be attributed to the fact that storage at room temperature tends to increased lactose fermentation which lead to a decreased in pH-values. Wahba and El-Abbassy (1982) reported that the pH values progressively decreased during the storage with a pronounced drop in the first month. Similar findings were obtained by Walstra *et al.*(1987) ; Hamid (2005) and Hatem *et al* .(2012) who reported that, pH values progressively decreased during storage. Our results were also supported by those of Kamal and Babiker (2009) and Abdel- Razig and Abdalla (1997) who stated that pH decreased with the storage period.

The above results were not in agreement with those of Ali and Abdel-Razig (2011); El-safty *et al.* (2004); Koiskowaki (1997) ;El-Koussy *et al*.(1995) and Masoud (2008) who stated that the increased of pH values could be due to an

increased in the titratable acidity of the cheese samples which activated by the natural micro flora of raw milk as the result of lactose fermentation which lead to increased in pH-value.

Data in table 9 showed that acidity of the cheese samples increased during the storage period. These results were in agreement with the work of Dervisoglu and Yazici (2001) ; Hayalogu *et al*. (2008) ; Tarakci and Kucukoner (2006) and Zekai *et al*.(2004) who reported that the increased in the acidity is due to increased in the lactic acid by the action of lactic acid bacteria present in the raw milk. Similar findings were reported by (Wlstra *et al.,* 1999).

Hamid (2014) supported our results when he used three levels of cumin oils in the manufacturing of a Sudanese white soft cheese and he reported that titratable acidity increased with the storage period.

Our results contradicted those obtained by Osman and Nuser (2009) who studied the acidity content of a vacuum packaged white cheese and they found that it decreased with the storage period. The decreased of acidity probably could be due to the consequence of acid assimilation by yeasts and moulds (Coskun, 1998).

The volatile fatty acid increased from the beginning of the storage up to the end (Table 9). The increased of the volatile fatty acid probably could be attributed to the lipolytic action of the organisms on fat contents during the cheese ripening (Esponda *et al*.1983 and Abdel Razig, 1996).

These finding were in consistent with those of Abdel-Razig (1996); El-Owni and Hamid (2008) and Kandeel *et al*.(*1991*). Similar results were obtained by Hatem *et al*. (2012) who stated that total volatile fatty acid increased with the storage period in Ras cheese of the Mediterranean countries.

5. 6. Effects of the storage period on vitamin C and minerals contents of the Sudanese white soft cheese:

Vitamin C content of the white soft cheese decreased during the storage period (Table 10). These decreased could be due to the lipolytic activity of microorganisms on vitamin C resulting in a leakage of some vitamin C from the curd into the pickling whey (Khalid 1991; Nofal *et al*., 1981 and Nusur, 2001).

Calcium contents of the cheese samples decreased gradually throughout the storage period (Table 10). Dariani *et al*. (1980) stated that the decreased of calcium contents could be explained by the degradation of calcium or dissolution of calcium into the pickling solution. The loss in calcium content could also be attributed to the increase in acidity (E1 - Abd *et al*., 1982). These results confirmed those of Abdalla *et al*., (2013) who showed that calcium of the Sudanese white soft cheese decreased with the storage from day zero up to day 180.These findings were also agreed with those obtained by Abdel Razig (2000) who stated that the calcium content of the cheese decreased as the storage time progressed. Wong *et al*., (1988) reported that the solubility of calcium and phosphorus salts in the acidic medium lead to the loss of both of them.

Our results were in disagreement with those of Amer (2008) who stated that Ca increased with the storage period in Ricotta cheese. Buruiana and Zeidan (1982) and El-Abd *et al*.(1982) stated that increased in calcium content was attributed to the loss of moisture content of cheese.

Significant decreased in sodium of the cheese was observed throughout the storage period (Table 10). The decreased of the sodium with the storage could be due to the degradation of Na into the pickling whey (El-Abd, 1982). These results were in harmony with those reported by Abdalla and Hassan (2013) who showed that sodium contents of the Sudanese white cheese decreased with storage period. These results also coincided the work of Abdel-Moneim *et al*.(2012) who realized similar decreased in sodium content of

Mozzarella cheese made from cow's , goat's and a combination of 1:1 percent of the two milk.

These results were different from the values recorded by Mian (2008) who notice that Na of cheese increased with the storage period from first day up to day 120 of storage. Cimino *et al*. (1991); Mahran *et al*. (2000) and Abdel-Razig *et al*. (2000) attributed the high sodium content of cheese to the high loss in its moisture content.

Potassium (K) decreased with the storage period (Table 10). The decreased of potassium contents could be probably due to the lipolytic activity of microorganisms on potassium resulting in a leakage of some potassium from crude into the pickling whey (Khalid, 1991; Nofal *et al*., 1981 and Nusur, 2001). Theses findings were different from those obtained by Elnaz *et al*.(2014) who demonstrated that (K) of the Kurdish cheese increased with the storage period from day 1 up to day 60. Our results were also different from those of Mian *et al*.(2014) who explained that K of Cheddar cheese increased with the storage period.

In table 10 phosphorous contents of the cheese samples decreased from the beginning till the end of the storage period. The decreased in the phosphorous might be due to the degradation of phosphorus and loss of it in the pickling whey (Hayalogolou *et al*., 2005 and Abdlla, 1992). Similar decreased in P contents were found by Abdel Moneim *et al*.(2012) who studied the minerals contents of Mozzarella cheese made from milk of cow's, goat's and mixture of the two milk (1:1%). Gonzalez *et al*., (2009) added that during cheese ripening some of the minerals salts may migrate from the central part towards the external layer of the cheese.

5. 7. Effects of the storage period on the microbiological characteristics of the Sudanese white soft cheese:

Results in table 11 showed that total bacteria count increased with the storage period from day zero up to day 60 and then decreased. The increased of total bacteria count during the early storage period (day 0-60) could be attributed to rapid growth of microorganisms, while the decreased in day (90) may be attributed to lactic acid production as stated by Nour El Diam and El Zubier (2006). The same results were obtained by Zekai *et al.*(2004) and Badmos and Abdul Salam (2012) who indicated that total bacteria count increased with the storage period up to day 60 and then decreased. Similar results were reported by Abdalla *et al.*(2012) who studied the total bacteria count of a Sudanese white soft cheese stored in five different containers and found the total bacteria count increased from day zero up to day 75 of the storage period and then decreased.

Our results were also in agreement with those of Ur-Rehman *et al*. (2000) and Ceylan *et al*. (2003) who indicated that total bacteria of the cheese increased during the storage period due to microbial count of raw milk. Ahamed and Alhassan (2010) reported that total bacteria count increased with the storage period in two containers (plastic and metal) from day zero up to day 84 and then decreased. However, our results were not in accordance with those of Kheir *et al*. (2011) who stated that total bacteria count decreased with the storage period from day 1 up to day 90 in a Sudanese white soft cheese. Similar decreased in the total bacteria count were noticed by Barakat (2009) who studied the total bacteria count of Domiati cheese made with the cells of *Lactobacillus reuteri* and he found that the log of total bacteria count was 8.9±0.029, 8.76±0.066, 8.72±0.014 and 8.59±0.020 cfu/ml at day zero, 30, 60, and 90 of the storage period respectively. Our results were also in disagreement with those of Kamal

and Babiker (2009) who reported that total bacteria count decreased with the storage period in a cheese made with the acidifying agents.

Lactobacilli decreased with the storage period (Table 11). The decreased of lactobacilli count could be attributed to lactic acid production (Nour El-Diam and El Zubeir, 2006). These results coincided with those of Kheir *et al*.(2011) who noticed that lactobacilli of the Sudanese white soft cheese made from *Solanum dubium* extract and rennet decreased with the storage period from day 1up to the end of the storage period (day 90). These results were also in line with those reported by Sousa and Malcata (1997) who reported that lower lactobacilli count were found in the cheese manufactured with plant rennet until 28 days of the ripening. The same results were obtained by Edgarayan *et al*.(2007) who stated that lactobacilli decreased during the storage in Bulgarian white cheese made from a starter culture composed of *lactobacilli* and *lactococci*.

Results in table (11) showed that streptococci count decreased during the storage period. The decreased of streptococci count could be attributed to lactic acid production (Nour El-Diam and El Zubeir, 2006). These results were in consistent with those recorded by Kheir *et al*.(2011) who notice that streptococci of white cheese made from *Solanum dubium* extract and rennet decreased from day 1 up to day 90 of the storage period. Abdala *et al*. (2011) mentioned that streptococci decreased with the storage period from day zero up to day 90 in a Sudanese white soft cheese made with *Solanum dubium*. However these results were different from those of Zekai *et al. (*2004) who indicated that a lactic acid bacterium which is composed of (Streptococci and lactobacilli) increased with the storage period up to day 60 and then decreased.

Yeasts and moulds increased with the storage period (Table 11). The increased of yeasts and moulds during storage might be due to the fact that yeasts and moulds could metabolize the lactic acid and lower pH value

(Turkoglu *et al.*, 2003). These findings supported the results of Abdalla *et al.*(2012) who studied the yeasts and moulds count of a Sudanese white soft cheese stored in five different containers and he explained that its increased from day zero up to day 75 of the storage period. However Nour El-Diam and El-Zubeir (2007) reported that heat treatment and processing improve the cheese quality by reducing the counts of yeasts and moulds.

Results in table 11 showed that coliforms count decreased with storage period and completely disappeared at the end of the storage. The disappearance of the coliforms could be due to the decreased of the pH of the cheese as stated by Ali and Galal (2002). These results were in accordance with the work of Ahamed and Alhassan (2010) who reported that coliforms bacteria count decreased with the storage period from day zero up to day 84. Our results were also in line with those of Zekai *et al.*(2004) who indicated that coliforms count decreased with the storage period up to day 30 and then did not found at the day 60 and 90 of the storage.

Our results were also in harmony with the results of El-Owni and Hamid (2009) who realize similar decreased of coliforms in a Sudanese white soft cheese stored in two different containers from day 60 and then were not detected at the day 120 till the end of the storage period at day 240.

Staphylococcus aureus decreased with the storage period (Table 11).
This could be explained by the decreased of the pH values of the cheese because *Staphylococcus aureus* can not metabolize the low pH. Our results agreed with those found by Barakat *et al*.(2009) who studied the *Staphylococcus aureus* of Domiati cheese made with the cells of *Lactobacillus reuteri* and he revealed that it decreased with the storage period. These results were different from those of Abdul malek and Abdulaziz (2011) who showed that *Staphylococcus aureus* .increased with storage from day zero up to day 7 in the local Yemeni cheese

Our results were in disagreement with that notice by El-Owni and Hamid (2009) who stated that *Staphylococcus aureus* count in a Sudanese white cheese were detected only at day zero before storage and completely disappeared after 60 days. Ali and Galal (2002) noticed the growth of *Staphylococcus aureus* in a cheese made from raw milk up to day 90 and then it disappeared; he attributed the disappearance of *Staphylococcus aureus* to the increased acidity of the cheese and the high salt levels. Zekai *et al*.,(2004) indicated that *Staphylococcus aurues* increased with the storage period up to day 15 and then decreased.

Our results were not in line with those of Kamal and Babiker (2009) who did not found any *Staphylococcus aurues* in a Sudanese white soft cheese made from lemon, orange and grapefruit juices. The presences of the *Staphylococcus aureus* in the cheese from day zero up to the end of storage period might be due to the poor sanitary conditions and contamination of cheese during processing and storage (Santos and Genigeorgis, 1981).

5. 8. Effect of the storage period on the sensory characteristics of the Sudanese white soft cheese:

Results in table 12 indicated that there were significance change ($p<0.05$) by the storage period in all the characteristics under investigation (color, flavor, texture, taste, saltiness and over all acceptability. These results confirm the results of (El-Owni and Haimd, 2008) who revealed that there was significance change in a color, flavor and texture of the Sudanese white soft cheese during the storage. However the color, flavor, texture, taste, saltiness, and over all acceptability were decreased gradually with the storage period. These results supported the results obtained by Ayar (2002) and Hussein (2004) who demonstrated that sensory characteristics of the cheese decreased with the storage period.

These results were in disagreements with the work of Tarakci and Kucuknoer (2006) and Mohamed (2011) who reported that all the sensory characteristics of the cheese increased during the storage.

The best values for color, flavor, texture, taste and over all acceptability were obtained at the first day of the storage period, while the highest values for the saltiness were recorded at day 30.

These results coincided with those of Zekai *et al*.(2004) who indicated that the best values for the sensory characteristics of the cheese were obtained at the first month of the storage period. Our results contradicted the findings of Elnaz *et al*.(2014) who reported that the best values for the sensory characteristics of the Kurdish cheese were obtained at the second month of the storage period.

5. 9. Effect of different levels of cassava powder and storage period on the physicochemical characteristics of the Sudanese white soft cheese:

Total solid of the cheese samples decreased with the levels of cassava and increased with the storage period (Table 13). These results contradicted those of Mohamed (2011) who used different levels of cotton seed oil and Ground nut seed oil to manufacture the Sudanese white soft cheese and reported that total solids increased with both the levels of cotton seed oil and the storage time. Similar results were obtained by Ali (2011) who used different levels of *Salnum dibum* in cheese manufacturing.

Results presented in tables 14 and 15 showed that fat and protein increased with the levels of cassava and decreased with the storage period. Our results were not in line with those of Adam (2011) who studied the fat and protein content of white cheese made with different levels of black cumin and he revealed that it increased with the addition of black cumin and storage

period. His results have been supported by Hamid (2014) when he used three levels of cumin oils in the manufacturing of a Sudanese white soft cheese and he stated that fat and protein increased with the levels of cumin oil concentrations and storage period. These results were also different from those of Foda (2010) who used six levels of Spearmint essential oil ranged from (0.5 to 2.5 ml/kg) to manufacture the white cheese and he concluded that fat and protein decreased with the levels of Spearmint and increased with the storage period. Suliman *et al.*,(2013) notice that fat of the white cheese increased with both level of fat and storage period.

Results recorded in tables 16, 17, 18 and 19 showed that acidity, pH, volatile fatty acids and ash increased with the levels of cassava and storage period. These results were in consistent with those reported by Ali (2012) who used different levels of skim milk to manufacture the labenh cheese and reported that all these characteristics increased with both the levels of skim milk and storage period. In addition to that El-Tantawy *et al.(*2006) who studied the physicochemical characteristics of white soft cheese made from Goat's milk supplemented with different levels of Cardamom powder demonstrated that total volatile fatty acid decrease with levels of cardamom powder and increased with storage period.

5. 10. Effect of different levels of cassava powder and storage period on vitamin C and minerals content of the Sudanese white soft cheese:

Results in tables 20, 21, 22, 23 and 24 showed that vitamin C, Ca, P, Na and K were all increased with the levels of cassava and decreased with the storage period. The increase of these elements and vitamin C with the addition of cassava could be explain by their high levels in cassava powder which resulted in a cheese with high levels of vitamin C and other minerals, while their decreased with the storage period could be probably due to the lipolytic activity of microorganisms on these elements and vitamin C resulting in a

leakage of some minerals and vitamin C from curd into the pickling whey (Khalid 1991 and Nofal *et al*., 1981). Similar results were reported by Naveed *et al*.(2008) and Okorie and Adedokum (2013).

5.11. Changes in the microbiological quality of the Sudanese white soft cheese as affected by cassava powder and storage period:

Results in table 25 indicated that total bacteria increased with the levels of cassava and storage period till the day 60 and then decreased. Amer (2008) reported that total bacteria count increased with the acidifying agents and storage period. Similar results were obtained by Nour El Diam and El Zubier (2006) who used two different levels of fat (2.2 and 4.4 %) in the manufacturing of the cheese and they noticed that total bacteria count increased with the levels of fat and storage period.

Our results contradicted the findings of Alsawaf and Alnaemi (2011) who studied the effect of *Nigella sativia* seeds on some poisoning and pathogenic bacteria of a white cheese made from ewe's milk and he stated that total bacteria count decreased with the levels of Nigella seeds and the storage period.

Tables 26 and 27 showed that lactobacilli and streptococci decreased with the levels of cassava and storage period. Similar results were obtained by Khier and Osman (2011) who studied the effect of *Solanum dobium* on the cheese microbiology and they explained that lactobacilli and streptococci decreased with the used of Solanum and the storage period.

Results in table 28 showed that yeasts and moulds decreased with the levels of cassava powder in most samples and increased with the storage period. These results were in line with those reported by El-Tantawy *et al*.(2006) who used different levels of cardamom powder in the manufacturing of the cheese. Adam (2011) said that yeasts and moulds of cheese made from different levels

of black cumin decreased with the storage period and increased with the levels of black cumin.

Coliforms count increased with the levels of cassava and decreased with the storage period (Table 29). These results were in harmony with those reported by Nour El Diam and El Zubier (2006) who reported that colifroms content increase with the levels of fat and storage period. Zekai *et al.*,(2004) used three levels of salt concentration (4 , 5 and 6 %) in the manufacturing of the Turkey cheese and he mentioned that coliforms increased with the levels of salt concentration and storage period up to day 30 and were not found in the end of the storage period.

Staphylococcus aureus count increased with the levels of cassava and decreased with the storage period (Table 30). Similar results were obtained by Alsawaf and Alnaemi (2011) who studied the effect of *Nigella sativia* oil on some poisoning and pathogenic bacteria of a white cheese made from ewes milk and he found that *Staphylococcus aureus* count decreased with the levels of *Nigella sativia* oils and storage period.

5.12. Effect of different levels of cassava powder and storage on the sensory characteristics of the Sudanese white soft cheese:

Results in Tables 31, 32, 33, 34, 35 and 36 showed that color, flavor, texture, taste, saltiness and over all acceptability of cheese decreased with the level of cassava and storage period. These findings supported the work of Ahamed and Mervat (2012) and Kosikowski (1982). Similar results were also obtained by Foda (2010) who stated that storage period negatively affected the sensory characteristics of the white cheese made from different levels of spearmint oil.

5.13. Effect of the different levels of cassava powder on yield of the Sudanese white soft cheese:

Yield of the cheese increased with the addition of cassava powder (Table 37). This could be explained by denaturing of whey protein and higher retention of water in the soft curd formed (Zaki *et al*.2004 and Abdel Razig, 1996), it could also be explained by the effect of cassava powder on the cheese proprieties by holding a high moisture in the cheese curd resulting in releasing of small amount of whey which finally gives the cheese made from cassava higher yields. Ustunol and Brown (1985) stated that yield of cheese increased due to the incorporation of whey proteins. These results were in line with those of Abdual-Rahaman (2013) who stated that the white soft cheese yield increased with the levels of safflower seed extract. Our results were also in accordance with those of Okorie and Adedokum (2013) who used different levels of Bambaranut milk (5, 10, 15, 20, 30, 40 and 50) to manufacture the Nigerian Warankashi white soft cheese and he stated that yield increased with the levels of the Bambaranut milk.

However, our findings were different from those reported by Igyor *et al*. (2006) who recorded a decline in the percentage of the cheese yield as there were increased in a soymilk supplementation. Fashakin and Unokiwedi (1992) reported that yield of the cheese remained relatively constant with the levels of soy milk substitution.

Makki (1987) found the yield of Queso blanko cheese made under Sudan condition ranged between 14-16.5%. Driani *et al*.,(1980; Babkier (1987) and Ahamed and Khalifa (1989) reported a high yield of milk cheese between 9-19.2 %. Farkey (2004) reported that its range between 9-15 % and Abdel razig (1996) reported that the yield of cheese is 19.08%. Ahamed (1985) found that the yield of cheese ranged from 22.9-23.8%, while Khalid (1991) reported that the maximum values for the yield of the white cheese was about 27.80 %. This variation in the yield of cheese might be related to different heat treatments and sources or composition of the milk (Mohamed, 2011).

Chapter Six

Conclusions and Recommendations

6.1. Conclusions:

:From the results obtained in this study following conclusions can be given

1-The different types of cheeses obtained in this study were of good standards, quality, attractive with better consistency clean and with good flavor without gas holes or bad odor.

2- The cheese yield increased with the levels of cassava powder the highest yield was recorded by cheese made with 1 % cassava and the lowest one was obtained by the cheese made without cassava.

3- Cassava levels significantly ($P<0.05$) affected the total solids, fat , protein , acidity and volatile fatty acid while there were no significant effects on pH and ash.

4- The storage period significantly (P<0.05) affected the total solids, fat, protein, acidity, volatile fatty acid and pH while there was no significant effects on ash.

5- Vitamin C, Ca and P were significantly (P<0.05) affected by the levels of cassava while there were no significant effect on Na and K all these characteristics increased with the levels of cassava.

6- Vitamin C and minerals contents of the cheese were significantly (P<0.05) affected by the storage period, and it's decreased with the progress of the storage period.

7- The microbiological characteristics of cheese (Total bacteria counts, lactobacilli, streptococci, yeasts and moulds and *Staphylococcus aureus*) were significantly (P<0.05) affected by the levels of cassava, while there was no significant effect on coliforms.

8- The storage period significantly (P<0.05) affected the microbiological characteristics of the cheese.

9- Total solids and pH decreased with the addition of cassava, while fat, protein, acidity and volatile fatty acid increased.

11-Vitamin C and minerals contents of the cheese were significantly (P<0.05) affected by the storage period. All these characteristics decreased with the storage period.

12- Cheese made with 1% cassava obtained the best values for vitamin C and minerals contents.

13- The cheese made without cassava obtained the best values for color, texture, taste and over all acceptability.

14- The best microbiological quality was obtained from the cheese made with 0.5 % cassava and the worst one was obtained from the cheese made without cassava.

15- The Sudanese white soft cheese made from milk without cassava (control) obtained the maximum values for the, lactobacilli, streptococci, yeasts and

moulds and *Staphylococcus aureus*, while the maximum total viable bacteria count was obtained by cheese made with 0.5 % cassava and the maximum coliforms was obtained by cheese made from 1 % cassava powder.

6.2. Recommendations:

From the results obtained following recommendations can be given:

1- Pasteurization of milk with high temperature (More than 72°C for 1 minutes) when high percentages of cassava levels were used in the manufacturing of white cheese to avoid bitterness and clotting and to reduce the microbiological load of the final products.

2- Investigation of the nutritional values of cheese made from cassava to asses its micro content of vitamins and minerals rather than those have been studied in this study.

3-Storage of cassava cheese at room temperature for long period of time is not advisable for it changes the appearance and acceptability and increased the microbiological load.

4- Application of Arabic gum together with cassava when high percentage of cassava used in the manufacturing of Sudanese white cheese to avoid weakness of the texture and body.

5- Use of cassava powder in the manufacturing of other dairy products such as mish, yoghurt…etc.

6-Investigation of similar studies on Sudanese white cheese made from other milk (Sheep , Goat , Camel , Buffalo , mixture of two milk or more , ….etc).

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Appendices

Appendix (I): Sensory evaluation sheet for white cheese:

Samples	Color	Taste	Texture	Flavor	Saltiness	Overall acceptability
1.						
2.						
3.						
4.						
5.						
6.						
7.						
8.						
9.						
10.						

Color:	Taste:	Texture:	Flavor:	Saltiness:	Overall acceptability
1- Highly desirable 9	1- Highly palatable 9	1- Highly consistent 9	1- Highly normal 9	1- Highly salted 9	1- Highly acceptable 9
2- Very desirable 7	2-Very palatable 7	2- Very consistent 7	2- Very normal 7	2- Very salted 7	2- Very acceptable 7
3- Desirable 5	3- Palatable 5	3- Consistent 5	3- Normal 5	3- Salted 5	3- Acceptable 5
4- Less desirable 3	4- Less palatable 3	4- Less consistent 3	4- Less normal 3	4- Less salted 3	4- Less acceptable 3
5- Un desirable 1	5- Un palatable 1	5- Un consistent 1	5- Up normal 1	5- Un Salted 1	5- Un acceptable 1

Appendix (II):

Photos:

Photo (1) Cassava roots

Photo (2) Peeling of cassava roots

Photo (3) Fresh cassava peels

Photo (4) Washing of cassava peels

Photo (5) Cutting of the peels

Photo (6) Drying of cassava peels

Photo (7) Dry cassava peels

Photo (8) Mincing of cassava peels

Photo (9) Cassava powder (Taken from website)

Photo (10) Cow's raw milk

Photo (11) Pasteurization of the milk

Photo (12) Container for cheese processing

Photo (13) Adding of rennet

Photo (14) Adding of Calcium chloride

Photo (15) Transferring to a wooden frame

Photo (16) Whey separation

Photo (17) Pressing over night

Photo (18) the pressed cheese

Photo (19 and 20) Prof. Omer (My Supervisor) explaining how to cut the cheese.

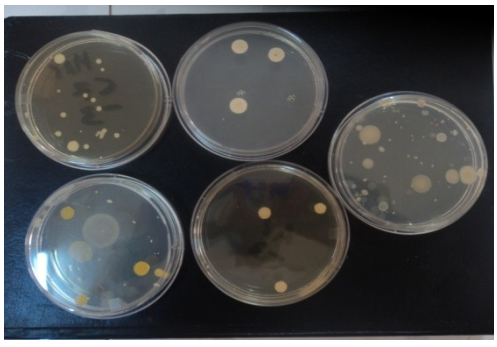
Photo (21) cheese after cutting **Photo (22) cheese in plastics cans**

Photo (23) storing at room **Photo (24) Determination of acidity**

Photo (25) Total bacteria count **Photo (26) anaerobic jar**

Photo (27) Colony counters Photo (28) Fat determination

Photo (29 and 30) Panel test in laboratory of dairy science and technology



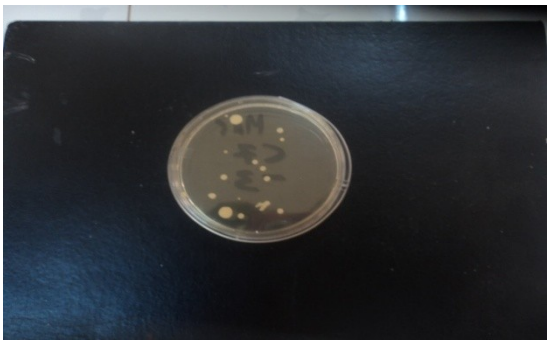


Photo (31) Microbiological results (Day 90) **Photo (32) Lactobacilli count (Day 90 Cw2**)**

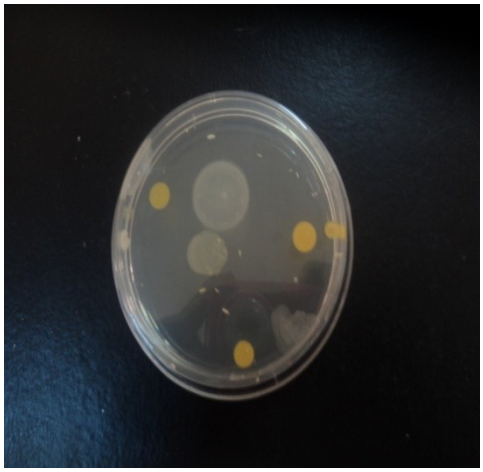


Photo (33) Total bacteria count (day 90 cw2[**]) **Photo (34) Streptococci count (Day 90)**

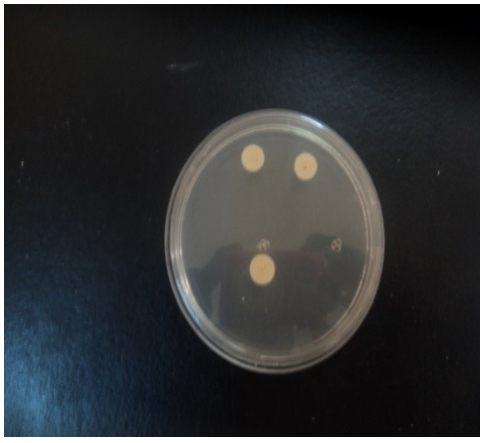


Photo (35) Yeast and moulds (Day 90 cont.) **Photo (36) Coliforms negative (Day 90) cont[*])**

*Cont. = Cheese without cassava powder (control).
**Cw2= Cheese with 0.75 % cassava powder.