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EFFECT OF VARIETY AND PROCESSING TEMPERATURE ON THE YIELD, QUALITY AND SHELF-LIFE OF MILK PRODUCED FROM THREE VARIETIES OF SOYBEANS BY THE VITAGOAT SYSTEM

BY

ATUAHENE EMMANUEL

JUNE, 2016

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A THESIS SUBMITTED TO THE SCHOOL OF RESEARCH AND GRADUATE STUDIES, KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY IN PARTIAL FUFILMENT OF THE REQUIREMENTS FOR THE AWARD OF DEGREE OF MASTER OF PHILOSOPHY IN SCIENCE (POSTHARVEST PHYSIOLOGY)

JUNE, 2016

DECLARATION

I do hereby declare that this thesis is as a result of my own original research and no part of it has been presented in this university or elsewhere, except references to other people's work which have been duly cited.

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DEDICATION

I dedicate this work to my better half, Agartha and my three wonderful daughters, Christine, Justine and Julia for their patience for me while I undertook this programme.

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I wish to express my profound gratitude to the Almighty God for His guidance and protection throughout the course.

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ABSRACT

Three improved varieties of soybean, Anidaso, Nangbaar and Quarshie were used in the study to determine the effect of variety and processing temperature on the yield, quality and shelf-life of soymilk produced by the VitaGoat processing system. Two kilograms of each of the varieties were processed into soymilk at three temperatures, 110^{o}C, 115^{o}C and 120^{o}C. The yield of each variety at the various temperature levels was measured by the total volume the soymilk produced. Three samples of the soymilk from each variety were randomly selected for proximate analysis. Five samples were also randomly selected, kept at room temperature and monitored daily for three weeks to determine their shelf-life based on spoilage by coagulation. The yield of soymilk produced by Nangbaar was significantly ($p<0.01$) higher than that of Anidaso and Quarshie. For processing temperature, soymilk produced at 110^{o}C was significantly ($p<0.01$) higher than that of 115^{o}C and 120^{o}C. The interaction between Anidaso and 110^{o}C produced significantly ($p<0.01$) highest yield of soymilk than that of the other interactions. Anidaso produced significantly ($p<0.01$) highest content of protein than Nangbaar and Quarshie. Soymilk produced at 110^{o}C was significantly ($p<0.01$) highest in protein content than 115^{o}C and 120^{o}C. The combined effect of Anidaso and 110^{o}C was significantly ($p<0.01$) highest in protein content than that of the other combinations. The soybean varieties did not significantly ($p<0.01$) influenced the shelf-life of soymilk during the study. Soymilk produced at 120^{o}C was significantly ($p<0.01$) longer in shelf-life than that of 110^{o}C and 115^{o}C. Quarshie by 120^{o}C was significantly ($p<0.01$) longest in shelf-life than that of the other interactions. It is concluded that Anidaso at 110^{o}C is rated the best among the varieties and processing temperature for producing high protein content.

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CHAPTER ONE

1.0 INTRODUCTION

Soybean (*Glycine max*) is a grain legume crop native of Eastern Asia and several pacific Islands. It was first introduced into Europe about 1712 and into North America by 1764 but has now spread to many parts of the world because it can be grown in a wide range of soils and climates. Its spread from the native land of origin has also been due mainly to its predominant use as food crop for human nutrition, source of protein for animal feed, medicinal plant, and lately as industrial crop (Robert and Nemat, 1998).

By far, the largest commercial cultivation of soybean is in the USA, with Brazil as the second largest. In China, soybeans are mostly consumed by the local population (Singh *et al.,* 1987). The USA yearly production is more than 60 million tonnes of soybeans and exports half of the crop which values stands is about US $5 billion. Brazil, which before 1960 hardly grew any soybean, today exports close to 15 million tonnes annually, valued at about US $2 billion.

Soybean is a relatively new crop in Ghana. It was initially introduced into the country in 1909 for export and for animal feed but failed due to poor understanding of its cultivation and utilization. It has been tried a few more times after this in 1930s, 1950s, 1970s and 1990s but has failed (MOFA, 2005). Difficult cooking characteristics, taste, and loss of seed viability are some of the factors which have prevented the extensive cultivation and use of soybean in Africa and elsewhere despite its high protein content (Purseglove, 1997). The demand for soybean has increased after initial production of about 1,000 MT in 1990 to an estimated production of about 15,000 MT in 2004 (MOFA *et al.*, 2005) in Ghana.

Some institutions like, Food Research Institute, Department of Family and Consumer Sciences, University of Ghana and the Women in Agricultural Development Directorate of the MOFA have intensified since 1995 their effort in promoting the use of soy in the country and has undertaken an extensive recipe development in Ghana. Several recipes have since been developed (MOFA, 2005).

Soybean is known to be very important in our diets but how processing temperature affects the yield, the quality and even the shelf-life of different varieties of soybean when processed into soymilk needs to be identified (Gesinde *et al.*, 2008).

The "VitaGoat" is a post-harvest preparing system that can be utilized to make quality food products from oats, grains, nuts, vegetables and fruits, empowering households to build food security, enhance wellbeing and make small scale industries (World Soy Foundation, 2005).

VitaGoats can give protein-rich nourishment to individuals in emerging nations where lactose-intolerance is regular or where conventional dairy items are inaccessible or expensive. Around 100 VitaGoats have been installed in thirteen Africa nations and other different nations, for example, India, Thailand, Bangladesh and North Korea in the previous four years (World Soy Foundation, 2005). Through subsidy given by the SilkWhite Wave Foods, the World Soy Foundation (WSF) had the capacity to buy, transport and install a VitaGoat Machine in western Ghana. As a feature of its philanthropic administrations, ADRA (Ghana) is likewise working together with WSF (World Initiative for Soy in Human Health, WISHH) to undertake VitaGoat project to deal with malnutrition problems in Ghana using soy intervention. Pilot project has been set up at Mafihuta and

AMO Yaokope in the North Tongu and Dangme Districts in Ghana respectively, and also Techiman municipality, working with Valley View University, Techiman to reach basic schools in the area (ADRA- Ghana, 2011).

VitaGoat processing system makes use of temperature and pressure in the preparation of soymilk. Heat-based preparations can enhance the timeframe of realistic usability and wellbeing of a food item; it can likewise diminish the nourishing potential of foods and can produce off-flavours. For instance, warm treatment of soymilk can advance undesirable cooked flavors that can diminish utilization of soymilk (Kwok *et al.*, 1999). Once more, of the a wide range of components influencing the nature of soymilk, the most essential ones incorporate the soybean mixed bags and capacity conditions. The project was designed to determine the effect of three soybean varieties and processing temperature on the yield, quality and shelf-life of soymilk from the VitaGoat processing system and specifically to determine the:

1. variety and temperature for producing high yield of soymilk by the VitaGoat processing system;

2. variety and the processing temperature that gives the highest quality of soymilk produced by the VitaGoat processing system; and

3. shelf- life of the VitaGoat- produced soymilk as affected by the processing temperature and variety.

CHAPTER TWO

3.0 LITERATURE REVIEW

2.1 Botanical Classification and Description of Soybean

There are two subgenera of the genus *Glycine* Wild, *Glycine* and *Soja*. The cultivated soybean, *Glycine max* is among the sub-genus *Soja* and the wild soybean, Glycine soja. Both species are annuals. *Glycine soja* is the wild precursor of *Glycine max*, and develops wild in China, Japan, Korea, Taiwan and Russia (Singh *et al*., 2006). The sub-genera, glycine comprises of not less than 25 wild enduring species, for instance, *Glycine canescens* and *G. tomentell*, both found in Australia and Papua New Guinea (Hymowitz, 1995).

Soy shifts in development and propensity. The plant's stature differs from under 0.2 to 2m.

The stems, pods and leaves are encased in fine chestnut or silver hairs. The leaves are trifoliate, having three to four leaflets for each leaf. The leaves are 6–15 cm long and 2–7 cm broad. The leaves fall before the seeds are developed. The subtle, self-rich blooms are borne in the leaf's axil and are white, pink or purple.

The fruit is a bushy unit that develops in bunches of three to five; every case is 3–8 cm long and contains two to four seeds, 5–11 mm in diameter.

Soybeans come in different sizes, and in numerous structure or seed coat hues, including dark, chestnut, blue, yellow, green and mottled. The body of the full grown bean is hard, water-safe, and secures the cotyledon and hypocotyl (or "germ") from harm. On the off chance that the seed coat is broken, the seed won't grow. The scar, obvious on the seed

coat, is known as the hilum (hues incorporate dark, cocoa, buff, dim and yellow) and toward one side of the hilum is the micropyle, or little opening in the seed coat which can permit the retention of water for germination (Blackman *et al*., 1992).

2.2. GROWTH AND DEVELOPMENT OF SOYBEAN

2.2.1 Ecology

Soybean is well suited to different climatic and soil conditions. For maximum yields and production of a good quality soybean crop, climatic and soil conditions should be optimal. A growing season of 120 – 215 days with an annual rainfall of not less than 700mm, well distributed throughout the growing period is required. In Ghana, the Guinea Savanna and the Forest-Savanna Transition agro-ecological zones are the best environments for soybean cultivation. The crop also does well in the Semi-deciduous Forest and Coastal Zones (MOFA *et al.,* 2005).

2.2.2 Site Selection

Level land or land with gentle slope with a deep and well-drained loamy soil is good for maximum productivity. Sandy soils expose the land to drought stress, causing total crop failure since it has low water holding capacity. Clayey soils, prone to water logging, crust and crack when dry, can damage the rooting system (MOFA *et al*., 2005).

2.2.3 Choice of Variety

According to MOFA *et al*. (2005), six improved varieties are currently recommended for cultivation by farmers in Ghana. They are high yielding, tolerant to important soybean diseases in Ghana such as bacterial pustule, frogele leaf spot, soybean mosaic virus and

bacterial blight. They also have high resistance to pod shattering; they modulate well and fix nitrogen with the native rhizobia species in African soil. The recommended varieties and their characteristics are presented below:

Table 2.1: Characteristics of current soybean varieties

Variety	Year Released	Institution	Maturity Class+	Pod Shatt ++	Ceral Striga Mgt*	Nodule Score **	% NDFA +	Seed Colour	Grain yield (Tons/ha) ++	Grain yield (bags/ha)
Salintuy-1	1992	SARI	Medium	MR	Fair	Good	Good	yellow	1.2 – 1.8	12 – 18
Anidaso	1992	CRI	Medium	R	Fair	Good	Good	yellow	1.2 – 1.8	12 – 18
Quarshie	2003	SARI	Medium	R	Very Good	Good	Good	yellow	1.5 -2.2	15- 22
Jenguma	2003	SARI	Late	R	Good	Very good	Very good	yellow	1.7 – 2.8	17 – 28
Nangbaar	2005	CRI	Early	R	Fair	Good	Very good	yellow	1.5 – 2.5	15 – 25
Ahoto	2005	CRI	Early	R	Good	Good	Good	yellow	1.5 – 2.2	15 - 22

Source: MOFA *et al*. (2005)

+ Maturity Class" Early (≤ 100 days), Medium (101 – 115) days, late (> 115 *days*) ++

Pod shattering rating: R = resistant, MR = moderately resistant.

*Cereal striga management: Gives an indication of the varieties' ability to cause suicidal germination of *striga hermonthica*

** Nodulation Score is rated poor = few small nodules; Fair = few nodules some large; Good = more nodules some large; very good = more large nodules and Excellent = plenty, of large nodules.

+ %NDFA (percent nitrogen derived from atmosphere) is rated poor (P) if it is $< 40\%$; fair (F) 40-50%, good (G) 51 – 60; very good (VG) 61 – 70 and excellent (E)$> 70\%$.

++ The yield estimates are based on mean on-farm and on-station yield.

2.2.4 The use of Good Seed

Seeds should be purchased from certified seed outlets where seed viability and variety purity can be guaranteed. Where certified seed is not available, seed from one's own farm can be used. In that case, it is important to demarcate an area in the middle of the field, just before or soon after flowering. Then harvest healthy plants from the demarcated area to provide seed for planting the following year. Diseased and insect pest infected plants in the area should be pulled out. All off-type plants, observed to be different from the variety purchased should also be pulled out and thrown away (MOFA *et al.*, 2005).

2.2.5 Planting

Planting should be done when rains have stabilized. The period of planting may differ according to the agro-ecology, maturity group of variety and the season (MOFA *et al.*, 2005).

Table 2.2: Planting period for the different agro-ecological zones in Ghana

Agro-ecology	**Early Maturity Groups (100 *days*)**	**Medium Maturing Group(101-115days)**	**Late-Maturing Group(Over115days)**
Guinea Savanna	Mid-June to July	Mid June-end July	Mid June-Mid July
Transition	Mid-April and July	July	July
Forest	Mid April and July	July	July
Coastal Savannah	Mid April and July	July	_

Source: MOFA *et al.* (2005)

Depending on the maturity of variety, both inter and intra row spacing used, and the method of planting, a plant population per hectare may range from about 175, 000 to 450,000. In Ghana plant populations of about 250, 000 for wide rows and 340, 000 for narrow rows give maximum yields.

Table2.3: Recommended spacing for planting soybean in Ghana

Between row Spacing (cm)	60	60	60	75
Within row Spacing (cm)	5	10	5	20
Seed(s)/hill	1	2	1	2-3(2rows on a ridge)
Expected plant pop/ha	318,200	333,300	318,200	266,700-400,000
Medium and late Varieties				
Between row Spacing (cm)	75	60	75	75
Within row Spacing (cm)	5	20	5	20
Seed(s)/hill	1	2-3	1	2(2rows on a ridge)
	On the flat		**on ridges**	
Early Varieties	**Drill**	**Dibble**	**Drill**	**Dibble**
Expected plant pop/ha	254,500	166,700-2-50,000	254,500	266,700

Source: MOFA *et al.* (2005)

2.2.6 After Planting Activities

Fertilizer application especially on poor or continuously cropped soils, weed control; either manual or chemical as well as control of insect pests, diseases, rodents and birds are all important for optimum yield (MOFA *et al.*, 2005).

2.3 CROPPING SYSTEM

2.3.1 Mono Cropping

Soybean is commonly grown as a sole crop. It has an advantage of achieving correct plant population per unit area. Again, it is easier to mechanize large field operations making it compatible with large scale production systems. However, in the event of an outbreak of disease and insect pests, total crop loss may occur (MOFA *et al.*, 2005).

2.3.2 Intercropping

In the Northern part of Ghana, Soybean – maize intercropping is mostly practiced. Traditionally, farmers plant cereals and legumes either in a random arrangement in rows. When they plant in rows, they plant the crops either in the same row or in alternate rows. It is recommended that farmers plant by alternating 1-3 rows of maize or sorghum with 2 – 5 rows of soybean for optimum yield from their field (MOFA *et al.*, 2005).

2.3.3 Crop Rotation

Two or more crops grown in alternation on the same land can significantly improve yield. Soybean is a favourable preceding crop to maize, cassava and sorghum. The success of the

system is determined by crop strain, cultivation of the right variety, sequence of cropping and farming practices (MOFA *et al.,* 2005).

2.3.4 Multi-strata System

Here the farmer plants short stature crops usually annual crops in open spaces between rows of the tree crop species which would otherwise be covered by weeds. Soybeans can be grown between rows of citrus, oil palm, and mango and timber species to supply extra income from the tree crop farm. This system is advantageous because the farmer benefit from the annual food crop even at a time the main crop (tree crop) is not producing economic yield (MOFA *et al.,* 2005).

2.3.5 Crop-livestock System

Soybean Stover can be fed to livestock as fodder especially during dry season when feed is scarce in Northern Ghana. The Manure of the livestock could also be collected and spread on the field to improve soil fertility (MOFA *et al.,* 2005).

2.4 Harvesting

The soybean in the field is almost ready for harvesting when the following are observed; yellowing and shedding of leaves, yellowing and drying of pods (90 – 95%) and seed, becoming hard and yellow (90%). The moisture content would be about 15- 18% at this stage. For high quality grain, harvest promptly when there is obvious colour change. Timely harvest helps to avoid field withering that result in grain deteriorating diseases, pest attack and infestation. There is also a minimum loss of crop to bush fire, theft and destruction by animals. Harvesting may be done manually (by hand) or mechanically (by machine). Harvesting at mid-morning or late afternoon helps to prevent shattering (IITA,

1990).

2.5 Post Harvest Handling of Soybean

After harvesting, the grains are desiccated to reduce about 13 percent of water. This makes threshing easy and prevents mouldiness. Air -drying of harvested seeds in the open for about 3-5 days before threshing whiles periodically turning helps to ensure even drying (MOFA *et al.*, 2005).

2.5.1 Threshing and Cleaning

If available, threshing of the dried soybean can be done with a winnowing machine. Manual threshing can be done by gently beating the dried beans when spread on a tarpaulin with flat stick. (MOFA *et al.*, 2005).

Cleaning must be done to remove foreign materials such as debris, weed and other crop seeds and soybean seeds that are damaged, immature or diseased. After proper drying the seeds should be put in woven sacks for storage (IITA, 1990).

2.5.2 Seed Storage

Bagged soybean seed must be stored in cold-rooms. Storing seeds under ambient conditions will result in loss of seed viability especially in the hot and humid environments such as those in Southern Ghana. The best storage conditions are 1-15^{o}C and 50-70 relative humidity (IITA, 1990).

2.6 Importance of Soybean

According to MOFA *et al.* (2005), soybean is important in Ghana and the whole world for several reasons. The major reasons include; Provision of employment and incomes to people, nutrition and health benefit from its consumption, contribution to soil fertility improvement and overall sustainable agricultural production.

2.6.1 Improved Nutritional Benefits of Soybean

As a food or feed crop, soybean has become the leading source of edible oils and fats, consisting of 20% of the world's supply of these nutrients. The seed contains about 21% oil and 40% protein, calculated on a dry weight basis. Soybean produces the highest protein yield per unit area of any crop. It has been called "yellow jewel", "great treasure", "nature's miracle protein" and "meat of the field". It is expected to be used as a weapon against world hunger (Robert and Nemat, 1998). Its oil is of high quality and cholesterol- free. The protein content is also of high quality and comparable to those of animal sources such as meat, egg and milk. The protein in human breast milk is considered the highest quality of protein in foods. Whole eggs, cow's milk, animal meats and fish follow in rank. Soybean comes close in protein value to these foods. But the quantity, weight for weight is greater in soybean than in other foods. For example, for every hundred grams of soybean there are Forty grams of protein where as in meat there are about Twenty grams. By eating soybeans with other protein containing food plants, such as maize, rice Sorghum or millet, total protein intake becomes as good in quality as that in meat, fish and eggs (IITA, 1990).

2.6.2 Health Benefits of Soybean

There is growing research evidence that consumption of soybean helps to reduce risk from heart diseases, cancer, osteoporosis, menopausal symptoms and many more.

Currently, it is used in infant foods/weaning food to control or prevent protein energy malnutrition (Kwashiokor) in children. It is also used to fortify various traditional foods such as gari, sauces, stew, soups, banku etc. to improve their nutritional levels without changing their taste or cooking time (MOFA *et al.*, 2005).

2.7 Soybean Products and their Preparations

Africa is facing increasing problems of malnutrition particularly protein deficiency. Soybeans can successfully be grown in African. People can easily use them in their diets and develop their own recipes to suit their taste (llTA, 1990). In Africa reactions have been mixed; 'Soybeans take too long to cool, taste bad' or worse' are poisonous or causes sterility.

However, the real problem may be lack of familiarity with the methods to use them effectively. Simple recipes using soybeans are not sufficient alone; they must be accompanied by methods of preparing soybeans that are relevant to Africans and applicable in African culture.

Among the commonly used soybean recipes in our homes are the soymilk, soy vegetable soup, soy- rice porridge, soy-potato patty, soy nuts and soy dhal curry.

2.10.1 Problems with Home Preparations

According to Singh *et al*. (1987), commercially, prepared foods made from soybeans, unless subsidized, are often too costly, the solution is to have people produce their own soybeans and use them in their homes. In some cases the food products made from the recipes in the home have poor texture or an objectionable flavour. For instance, moisture holds in solution the mineral salts and much of the nutrients and to some extent the materials that give distinctive flavour. So when moisture is lost, most of the valuable components are also lost (UASA National Nutrient Database, 2004). Again, a number of difficulties accompany the use of soybeans at home, including:

-Rapid spoilage when the soybeans or Soy products are soaked in water of poor quality at high ambient temperatures.

-The long cooking time, which wastes scarce fuel and

-The lack of wide appeal, of the cooked whole beans, especially when improper preparations have catalyzed the lipoxygenase enzyme, producing a beany flavour.

2.7.2 The Best Ways to Promote Home Preparations

According to Singh *et al.* (1987), the following must be observed in making soy products in the home:

-follow and closely adhere to a few basic concepts to control the off-flavour and to eliminate the anti-nutritional factors in raw beans.

-use methods that ensure a proper texture of the final product, use approaches that are simple and do not require sophiscated equipment,

-use techniques that shorten the preparation and cooking and

- develop high-quality products that can be used in ways acceptable to the local people.

2.8 The VitaGoat

Finding solutions to the stated problems in ensuring the best ways in promoting home preparations have paved the way for introduction of the VitaGoat processing system.The low-maintenance VitaGoat system was envisaged by Malnutrition Matters, a Canadian NGO, and its processing machine was manufactured in India by GD Machine (Pvt) Ltd. in Faribadad (Alliance for New Humanity, 2008). Essential nutrients can be prepared into flours, wet slurries and utilized "as is" or further cooked with steam, concerning soymilk and its different subordinates. The key component of the VitaGoat is that it can make these sustenance without the requirement for power; granulating is given through "pedal force" while cooking vitality is given by means of an imaginative and fuel-proficient steam evaporator. The full framework incorporates four parts: A Pedal or electric pounding/mixing framework, a steam heater, a weight cooking vessel and a channel press. The utilization of steam-infused weight concocting is to 10 times more energy-efficient than other traditional cooking methods. The framework cooks the soymilk at a temperature of 105^{o}C with a weight of 40-80 psi for 15-20 minutes (‘M’ & VitaGoat Technical and Operation Guide, 2012).

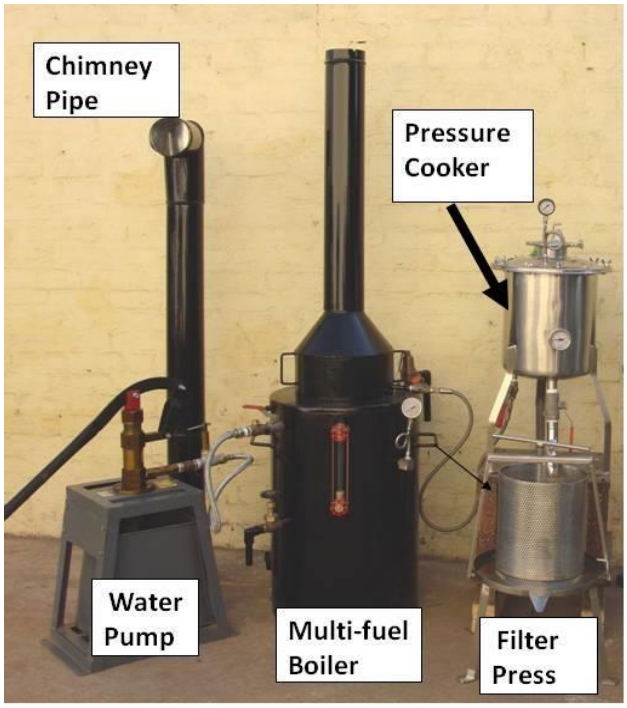

Fig. 2.1 The VitaGoat System

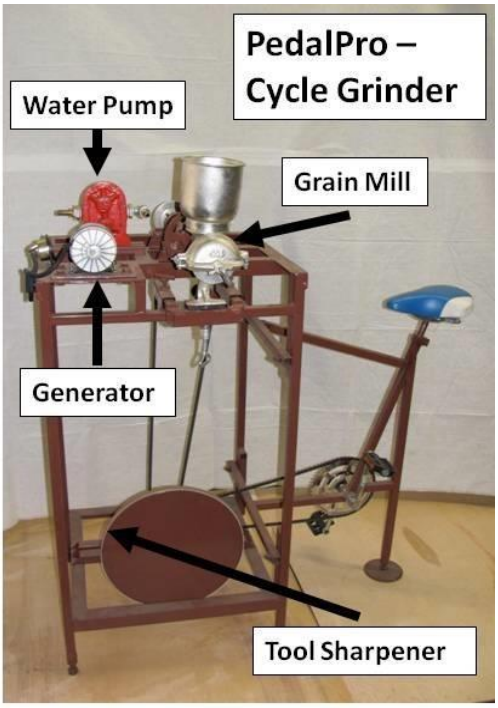

Fig. 2.2 The Pedal Grinder

Figure 2.3: The electric grinder

2.9 The Yield of Soymilk

Gesinde *et al.* (2008) identified a little significant difference on effect of variety on the yield of soymilk. Similarly, Bhardwaj *et al*. (1999) showed that soybean genotypes effects on soymilk parameters were significant except the yield and also identified that soymilk yield is also not correlated to seed characteristics and the processing temperature.

2.10 Proximate/ Nutritional Composition of Soymilk

Soybeans have high protein content, 40% by weight. The rest of the bean is made up of carbohydrates (32%), fat (20%), minerals (5%) and fiber (3%) together with moisture and trace quantities of other nutrients (llTA, 1990). Commonly, soymilk comprises of 94% dampness, 3.0% protein, 1.0% fat, 1.0% solvent sugars and 0.3% slag (Wilson and Erikson, 1995). The real proteins found in soybeans are glycinin (11s) and B-conglycinin (7s), making up roughly 40% and 30% of the aggregate protein, individually (Murphy *et al*., 2006). The proportion of these proteins changes among mixtures and can influence the nature of soymilk.

As indicated by Yuan *et al*. (2008), the utilization of ultra-high temperature is moderately new for soymilk creation; the conventional handling including temperature of 90-100 connected up to 30 minutes. However, Lozano *et al*. (2007) are of the perspective that warm preparing unfavourably influences the healthful and quality properties of soymilk and produces off-flavors. As a result of that, other handling techniques, for example, high weight have been connected. This is utilized as a part of the VitaGoat framework (Li *et al*., 2008).Again, warm treatment at the same time causes some diminishing in nourishment quality perspectives, incorporating misfortune in surface and healthful quality, loss of

dissolvable solids among others (Castro *et al*., 2006). Yu-Long *et al*. (2006) additionally found that soybean protein and sucrose altogether influenced inactivation of *Staphylococcus aurens* in milk by high weight and gentle warmth treatment and that for all soybean items warmth is important to demolish the protease's movement inhibitors actually display in the soybean. Sara (2011) additionally distinguished that warmth influences generally the vitamins and fat substance of food and the surface that they show. A few fats have the capacity to endure higher temperatures than others before coming to their 'smoke point' at which their compound structure is changed. These progressions have connected with wellbeing dangers, disagreeable smells, hindered flavor and diminished vitamin content. Also, the structure of proteins changes with warmth as well. This is basically because of a revision of its basic proteins. Then again, cooking procedures that include warmth make certain supplements accessible for the body to utilize.

It is presently realized that a mind boggling cooperation of elements, for example, soybean mixed bag and quality and preparing conditions influence the quality attributes of soymilk items (Arthur and Pawliszyn, 1990). At that point steady quality must be accomplished by comprehension these components and painstakingly controlling them amid preparing. So in the challenge of enhancing sustenance quality maintenance, new methods have been attracted with much thoughtfulness regarding nourishment handling and safeguarding (Denys *et al*., 2000) as in the VitaGoat framework.

2.11 Shelf-life of Soymilk

Shoppers interest for sheltered, added substance free and rack stable nourishments with ideal dietary and tactile qualities has driven the improvement of non-customary sustenance handling advances (Zink, 1997). It is important to adjust the change of item timeframe of realistic usability with expanding nourishment security while safeguarding tangible and dietary quality properties (McClements *et al*., 2001, Ortega-Rivas, 2007). These are the qualities the VitaGoat preparing framework has been set up to accomplish. Furthermore, soybean stockpiling conditions can influence the nature of soy items (Murphy *et al*., 2006). The level of warmth treatment is an imperative step on the grounds that it guarantees a protected sustenance item, inactivates lipoxygenase, annihilates hostile to nourishing elements, for example, trypsin inhibitors and can amplify the timeframe of realistic usability of the soymilk. On the other hand, issues emerge with warmth treated items including the generation of cooked flavors, which is a central point when attempting to create sustenance containing soy protein (Kwok *et al.* 1999).

Fresh soymilk has a very short shelf- life which limits consumption to areas close to the production site (Kwok *et al.*, 1999). According to Adebaya-Tayo (2009), the short shelflife is as a result of pH of the milk and the activities of the various micro-organisms contained in the milk which may have been inherently present in the soybean. Adeleke *et al.* (2000), reported processing and post-processing contamination as contributing factor to the short shelf-life.

Treatment temperature, level and duration of treatment and the amount of initial microflora affect the amount of microbes inactivated (Cheffel, 1995). So Kwok *et al.* (1999) say thermal processing

is the most common practice to improve the microbial safety and extend the shelf-life of soymilk because it inactivates vegetative pathogens and many spoilage bacteria.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Place of Production

The soymilk processing was carried out at Awurade Akwan Soymilk Factory, Agona in the Sekyere South district of Ashanti. The processing facility, the VitaGoat processing, system was established by Professor J.K Osei, formerly of the University of Ghana, Legon and the past rector of the Valley View University, Techiman Campus. The processing system was established in collaboration with the Malnutrition Matters to produce soymilk on daily basis for the local people to improve their general health in the area.

The processing facility has been carefully made to meet the standard of the Malnutrition Matters as required by the Soy Cow 'M' &VitaGoat Technical and operation guide. The standard seeks to ensure contamination- free soymilk produced. The standard requirements are listed below:

1. Production Room 'Wet Area' (see schematic on following page)
    a) Approx. 10 – 12 square meters minimum with a high ceiling.
    b) Large sink(s) or tubs for cleaning.
    c) Floor of cement or tile, preferably with floor drain or at least a place to wash spills out. Walls should also resist water and humidity.
    d) Good ventilation, with screened windows, fan or vents for air circulation.
    e) The boiler is to be located either in the corner of the room or directly outside the exterior wall from the other equipment. If it is to be located outside, it must be under a roof,

and not more than 1.5 meters from the inside equipment (a steam hose connects the boiler to the cooker.)

Chimney pipes of 3 meters and one 90 degree elbow are included with the boiler. This is to exit the room at the wall or directly exit the roof over the boiler. This must be done at the time of installation; some extra materials may be needed-please see drawings.

2. Dry Room for the storage of food supplies, etc.
   a) Not in the same room as the production area, to avoid splashing with water. Heat and humidity greatly speed the deterioration of the dry food.
   b) Dry room to have ventilation and protection from insects and rodents.
   c) Approx. 10 – 12 square meters of space
3. Utensils, and other furnishings required
   a) 2 medium size tables or work surface (about 1 m x 1.5 m)
   b) Vessels for the soaking of Soya beans:

   Minimum of 5 plastic pails-approximately 15 liters.
   c) A large quantity (5-10 sq. m.) of cheese cloth, gauze or muslin cloth for use in soymilk or other filtration and tofu production.
   d) 2 large cooking/ mixing spoons
   e) 2 large colanders or sieves (1 for the production of tofu and 1 for draining and rinsing soaked soybeans.)
   f) Vessels to contain and produce soymilk and other liquid products: Minimum of 5 pails – 15 – 20 liters each, clean and made of durable and washable plastic or steel g) 1 small step or box (approx. 30 cm or so.) to stand on to put food into top of cooker.

(cooker stands on table)

h) 1 large perforated spoon.

i) 1 large knife

j) 1 large ladle

k) A dowel or wood bar approximately 40 cm long and 4 diameter.

l) Rubber or plastic gloves and work boots. (Long – for protection of worker against hot splashes and for sanitary work.)

m) Work clothes or covers for all workers.

n) Cleaning materials including detergent and scrub brushes etc

o) A scale which weighs up to 5 kg.

4. Water

    1. A source of drinking water from a well.
    2. A water filter.

(SoyCow 'M' &VitaGoat Technical and Operation Guide, 2012)

3.2 Soybean Varieties used in the Project

Certified seeds of three improved varieties of soybean were collected from the CSIR, Fumesua and used in the project. The varieties were Anidaso, Nangbaar and Ouarshie; all released by the Crop Research Institute in the year 1992, 2005 and 2003, respectively. Two kilograms of each variety were used in the processing of the soymilk (Appendix 1).

The seeds were grown and harvested at a moisture level below 20%. They were stored at a moisture content of 14% and a temperature of 25ºC for about one year before being used.

3.3 Soymilk Processing Procedure

As required by the operation manual of the VitaGoat, soymilk was produced as follows:

- The 2kg of each of the varieties were soaked in clean water for eight hours. This made the seeds imbibe water to become soft enough to be milled by the electric grinder at the processing centre (Appendix 2a).
- For each batch of 2kg, twelve liters of clean water were added to the milled seeds and placed in the pressure cooker which was then covered tightly.
- Hot steam at a standard pressure of 40-80 psi from the boiler was introduced into the pressure cooker till the temperature rose to the temperatures needed for the project i.e. 110^{o}C, 115^{o}C and 120^{o}C for each batch of production.
- The cooking at each temperature; 110°C, 115^{o}C and 120^{o}C, were monitored for 15 minutes.
- The cooked soymilk at each processing temperature was slowly discharged to the press lined with a filter (Appendix 2b).
- The filtered soymilk was collected in stainless steel containers (Appendix 2c).
- The cooked soymilk was bottled hot from the stainless steel containers for each of the temperature regimes. 300ml sterilized bottles were used for collecting the soymilk (Appendix 2d).

3.4 Parameters Studied

Parameters studied were the yield, proximate composition and the shelf-life of the soymilk produced from the three varieties.

3.5 Experimental Design

The laboratory experiment was set-up in 3x3 factorial arrangement in a Completely Randomized Design (CRD) replicated three times.

The first factor was the variety with three levels; Anidaso, Nangbaar and Quarshie. The second factor was the processing temperature with three levels; 110°C, 115ºC and 120ºC.

3.6 Collection of Samples

At each processing temperature of the same variety, a number of sterilised bottles were used to collect the soymilk samples and labeled. The colour of the bottle tops were used in the labeling of the samples as follows:

Table 3.2: Labeling of samples

Variety	**Processing Temperature**		
	110ºC	115ºC	120ºC
Anidaso	Red	Yellow	White
Nangbaar	Silver	Blue	Green
Quarshie	Pink	Gold	Red/White

300ml sterilised bottles were used to collect soymilk samples at 110ºC, 115ºC and 120ºC for each variety. This helped in recording the whole quantity of milk produced by each of the varieties at each of the temperature levels.

The total number of bottles of each of the samples for the three varieties was used to compute the yield of each variety at the temperature levels.

Fives replicates of each of the samples were also kept for three weeks and were monitored on daily basis to determine their shelf- life.

Three replicates of the samples of each of the temperature regimes were randomly selected for proximate analysis. The laboratory analysis was carried out at the Soil Science Laboratory of Kwame Nkrumah University of Science and Technology, Kumasi, Ghana.

3.7 Data Analysis

The data collected was subjected to statistical analysis using analysis of variance (ANOVA). Statistical software used was the 9.0 version of the Student Edition of Statistix. Testing for the differences between the means was at 1% level ($p < 0.01$).

3.8 Method of Laboratory Analysis

The soymilk samples were evaporated at 105°C for 48 hours and the dry matter used for the proximate analysis.

3.8.1 Moisture Determination Principle

Moisture or water is usually determined by the loss in weight that occurs in a sample upon drying to a constant weight in an oven. The official method involves drying a representative sample in an oven at 95ºC – 110ºC for 24 hours or 2 hours at 135ºC. The moisture content of some feedstuffs which contain other volatile compounds, particularly short-chain fatty acids or fatty products cannot be determined by these methods. For these feedstuffs, distillation of the moisture in toluene is an acceptable method (Pellet and Young, 1980).

Dry Method (Indirect Distillation)

The moisture can or crucibles were weighed. Five (5) g of the sample was weighed and allowed to dry overnight in an air oven at 105ºC for 24 hours. Crucibles plus samples in desiccators were cooled and re-weighed.

Calculations

$(A + B) - A = B$

$(A + B) - (A + C) = B – C = D$

$\% \text{ Moisture} = D/B \times 100$

Where A = crucible weight, B = sample weight, C = dry sample weight, D = moisture weight.

3.8.2 Ash Determination

Principle

Ash is the inorganic residue obtained by burning a sample at 600ºC. Ashing of a feed sample burns off all organic constituents, leaving behind the non-volatile mineral elements. The temperature used for this determination may also affect some elements such as selenium and arsenic, which form volatile oxides when present. These losses can therefore be avoided by addition of known quantities of calcium oxide prior to ashing (Pellet and Young, 1980).

Procedure

Ash crucible was removed from oven, placed in desiccators, cooled and weighed. Two (2) g of sample was weighed into porcelain crucible in duplicate, put into furnace for 4 hours at 550ºC, allowed furnace to cool below 200ºC and maintain this for 20 minutes. It was then placed in the crucible in desiccators with stopper top, cool and then weighed (Pellet and Young, 1980).

Calculation

(A + B) – A = B

(A + C) – A = C

% Ash = C/B × 100 where A = crucible weight, B = sample weight, C = ash weight.

3.8.3 Ether Extract (Fat) Determination

Principle

Ether extract (fat) is a fatty acid ester of glycerol. The term lipid is used for all ether-soluble materials. Fats are those glycerol esters, which are solid, while oils are liquids at ordinary temperatures. Seeds like groundnut, soybean and cotton contain oil as reserved food material.

Ether extract is determined by extracting the dry sample with ether. The weight of the extract is determined after distilling the ether and weighing the residue. The ether extraction may be conducted with a suitable apparatus such as Soxhlet or a Goldfish extraction. Although this is the usual method for determining fat in feed, ether extraction does not remove all the fats, especially phospholipids fats bound to protein. Often acid hydrolysis followed by extraction of the hydrosylate with chloroform or ether is necessary to obtain 'total' lipid values (Pellet andYoung, 1980).

Procedure

A piece of filter paper was folded in such a way to hold the sample. Wrapped in 2nd filter and left open at the top like a thimble. A piece of cotton wool was placed at the top to evenly distribute the solvent as it drops on the sample during extraction. The sample packet was placed in the butt tubes of the Soxhlet extraction apparatus. It was extracted with petroleum ether for 2 hours without interruption by gentle heating. Then allowed to cool and dismantle the extraction flask. The ether was evaporated on a steam or water bath until no odour of ether remained, cooled at room temperature for overnight and carefully removed the dirt and moisture outside the flask and weighed the flask (Pellet and Young,

1980).

Calculations

(A + B) – A= B

% ether extract = B/C x 100

Where A = flask weight, B = ether extract weight, C = sample weight

3.8.4 Crude Fibre Determination

Principle

The carbohydrate of food is contained in 2 fractions: (1) the crude fibre and (2) the nitrogen – free extractives. Crude fibre refers to the organic residue of a feed that is insoluble after successive boiling with 0.255 N H_2SO_4 and 0.312 N NaOH solutions according to specified procedures. The determination of crude fibre is an attempt to separate the more readily digestible carbohydrates from those less readily digestible. The crude fibre fraction contains cellulose, lignin and hemicelluloses. Boiling a sample with dilute acid and alkali is an attempt to imitate the process that occurs in the digestive tract. This procedure is based on the supposition that carbohydrates, which are readily dissolved by this procedure, will also be readily digested by animals, and those that are not soluble under these conditions are not readily digested. At best, this is only a rough approximation of the indigestible material in feedstuffs, but quite a large part of it may in fact be digested by ruminant animal.

Nevertheless, crude fibre is used as a rough indicator in estimating the energy value of feeds. It is also valuable because of the correlation existing between it and the digestibility of the feedstuff (Pellet and Young, 1980).

Procedure

The weighed residue was transferred from the ether extract to a digestion flask. 200ml of the boiling H_2SO_4 solution and anti-foaming agent were added respectively and immediately connected digestion flask with condenser and heated. At the end of 30 minutes, flask, filter were immediately removed through linen and washed with boiling water until washings were no longer acid. A quantity of NaOH solution was heated to boiling point and kept at this temperature under reflux condenser until used. The residue was washed back into flask with 200 ml of the boiling NaOH solution, connected flask with reflux condenser and boiled for exactly 30 minutes. At the end of the 30 minutes, flask was removed and immediately filtered through the Gooch crucible. After thorough washing with boiling H_2O, it was washed with 15 ml of 95% ethanol. Crucible and contents were dried at 110^oC to constant weight, cooled in desiccators and weighed. Contents of crucible were incinerated in muffle furnace at 550^oC for 30 minutes until the carbonaceous matter were consumed. It was cooled in desiccators and weighed. The loss in weight was recorded as crude fibre (Pellet and Young, 1980).

Calculation

$$\% \text{ crude fibre} = \frac{A - B}{C} \times 100$$

Where A = wt. of dry crucible and sample

B = wt. of incinerated crucible and ash, C = sample weight

3.8.5 Crude Protein Determination

Principle

Nitrogen (N) is the real component by C, H and O_2 found in living things. In many proteins, N constitutes 16% of the aggregate make up.

The rough protein substance is ascertained from N substance of the food, dictated by an alteration of a system initially proposed by Kjeldahl. The small scale Kjeldahl procedure is received to evaluate the aggregate N content in an assortment of tests running from microbial cells to meat. With this system, the N in protein or whatever other natural material is changed over to ammonium sulfate by H2SO4 absorption. This salt, on steamrefining, frees NH3 which is gathered in boric corrosive arrangement and titrated against standard corrosive. Since 1 ml of 0.1 N corrosive is equal to 1.401mg N, figuring is made to land at the N substance of the example. It is accepted that the N is gotten from protein containing 16% N, and duplicating the N figure by 100/16 or 6.25, a surmised protein quality is acquired (Pellet and Young, 1980).

Procedure

Two (2) g of the sample was and put into a 30 ml digestion flask. One spatula full of Kjeldahl catalyst (potassium sulphate + copper sulphate + selenium powder mixture) and 20 ml concentrated H_2SO_4 were added to the digestion flask. Boiling chips were added to digest the sample till the solution became colourless. After the digest was cooled, it was diluted with a little amount of refined alkali free water and exchanged to the distillation

system. The Kjeldahl flask was flushed with progressive little amounts of water. A 100 ml funnel shaped flask containing 5 ml of boric acid solution with a couple drops of blended indicator with the condenser's tip plunging was set beneath the arrangement's surface. 10 ml sodium hydroxide –sodium thiosulphate arrangement was added to the test arrangement in the mechanical assembly. The alkali on boric acid was refined and gathered. The condenser's tip was flushed, and after that titrated the arrangement against the standard acid until the first appearance of violet shading, i.e. the end point. A reagent clear with equivalent volume of refined water was ran and subtracted the titrated volume from that of test titration volume (Pellet and Young, 1980).

Calculation

The N content of the sample can be calculated by the formula:

$$N\ (g\ kg^{-1}) = \frac{(ml\ HCl - ml\ blank) \times Normality \times 14.01}{Weight\ of\ sample\ (g) \times 10}$$

3.8.6 Carbohydrate (CHO) Determination

The total carbohydrate in the samples was determined by adding the percentages of all the other proximate compositions already determined and subtracting the calculated sum from 100.

CHO = (100-% moisture +% crude protein + %crude fat+ % crude fibre + % ash).

CHAPTER FOUR

4.0 RESULTS

4.1.1Effect of Variety and Processing Temperature on Yield of Soymilk

Analysis of variance indicated that, there was significant ($p<0.01$) difference in yield of soymilk produced by the different varieties used in the study. Statistically, the highest and lowest significant ($p<0.01$) mean yield of soymilk was recorded by Nangbaar and Quarshie respectively (Table 4.1). The study also revealed that, Quarshie was statistically different from Anidaso.

Regarding processing temperature, soymilk yields for the three temperature levels were significantly ($p<0.01$) different (Table 4.1). Processing soymilk at 110^{o}C resulted in the highest significant ($p<0.01$) mean yield followed by 115^{o}C with 120^{o}C recording the lowest ($p<0.01$).

The interaction between variety and processing temperature significantly ($p<0.01$) influenced the yield of soymilk (Table 4.1). The results showed that, the treatments were significantly different. At 110^{o}C, Nangbaar recorded the highest significant ($p<0.01$) soymilk yield compared to Quarshie which recorded the lowest soymilk yield value. The interaction between variety and processing temperature also revealed that, the treatments were significantly ($p<0.01$) different at 115^{o}C. The Nangbaar variety again recorded the highest significant ($p<0.01$) soymilk yield while Quarshie recorded the lowest soymilk yield (Table 4.1). Moreover, results of soymilk yield obtained at 120^{o}C was not different as Nangbaar significantly ($p<0.01$) had the highest soymilk yield value with Quarshie recording the lowest value.

Table 4.1: Effect of variety and processing temperature on yield of soymilk

VARIETY	PROCESSING TEMPERATURE			MEAN
	110^{o}C	**115**^{o}C	**120**^{o}C	
Anidaso	16.07bc	16.07cde	15.43efg	16.07b
Nangbaar	17.43a	17.00ab	16.27cd	16.90a
Quarshie	15.60def	15.13fg	14.77g	3.56c
MEAN	16.58a	16.07b	15.49c	
CV	1.78	1.78	1.78	1.78

CV = Co-efficient of variance. Means with the same letters within a column are not significantly different at 1% using L.S.D.

4.2 Varietal Effect on Proximate Composition

Results of the proximate composition of soymilk revealed that, the highest and lowest significant ($p<0.01$) fat values were recorded by Nangbar and Anidaso varieties respectively (Table 4.2a). The results also showed that, the best significant ($p<0.01$) protein and ash values were recorded by Anidado. No significant ($p<0.01$) effect of the treatment was experienced on protein between Naagbaar and Quarshie varieties. Moreover, the treatments significantly ($p<0.01$) influenced the moisture content of soymilk whereby the highest and lowest values were recorded by Nangbaar and Anidaso respectively. The results again showed significant ($p<0.01$) differences among the treatments with respect to carbohydrate (Table 4.2a). Quarshie was significantly ($p<0.01$) higher than Naangbaar followed by Anidaso in carbohydrate values.

Table 4.2(a): Varietal effect on proximate composition

Variety	Proximate Composition				
	Fat	Protein	Ash	Moisture	CHO
Anidaso	1.22c	33.42a	5.06a	4.33c	56.24c
Nangbaar	3.17a	29.75b	3.03b	5.85a	58.07b
Quarshie	1.58b	30.15b	1.70c	4.57b	62.23a
CV (%)	4.55	1.02	6.27	9.06	1.19

CV = Co-efficient of variance. Means with the same letters within a column are not significantly different at 1% using L.S.D.

4.2.1 Processing Temperature Effect on Proximate Composition

From Table 4.2b, the treatments significantly ($p<0.01$) influenced the proximate composition of soymilk fat during the study. While the highest significant ($p<0.01$) fat value was recorded at 120^{o}C the lowest fat value was recorded at 115^{o}C. Results obtained at the processing temperatures of 110^{o}C and 115^{o}C were not statistically different (Table 4.2b). With respect to protein, all the treatments were significantly ($p<0.01$) different. The best significant ($p<0.01$) soymilk protein value was recorded by the processing temperature of 110^{o}C followed by 115^{o}C with the processing temperature 120^{o}C recording the worst. The proximate composition for ash was not different as the processing temperature of 115^{o}C exhibited higher significance ($p<0.01$) ash value over processing temperatures, 110^{o}C and 120^{o}C that recorded the same ash values of soymilk. The results also revealed that, soymilk processed at115^{o}C was significantly greater ($p<0.01$) in moisture than the processing temperature of 110^{o}C of soymilk. However, soymilk processed at 115^{o}C and

120°C were not significantly ($p<0.01$) different in moisture content. In the case of carbohydrate, the best and worst significant ($p<0.01$) carbohydrate values were obtained at the processing temperatures, 120°C and 115°C respectively. Processing at 120°C was 2.55 and 5.39 higher in carbohydrate content than the processing temperatures, 115°C and 110°C respectively.

Table 4.2(b): Effect of processing temperature on proximate composition

Temperature	**Proximate Composition**				
	Fat	Protein	Ash	Moisture	CHO
110°C	1.83b	34.54a	3.00b	4.55c	56.11c
115°C	1.82b	30.08b	3.80a	5.20a	58.94b
120°C	2.32a	28.70c	3.00b	5.01ab	61.49a
CV (%)	4.55	1.02	6.27	9.06	1.19

CV = Co-efficient of variance. Means with the same letters within a column are not significantly different at 1% using L.S.D.

4.2.2 Interaction Effect of Variety and Processing Temperature on proximate composition

From Table 4.2c, the interaction between variety and processing temperature on proximate composition of soymilk fat revealed that, the treatments were significantly ($p<0.01$) different. The highest significant ($p<0.01$) fat content value was recorded by Nangbaar which was proceeded by Quarshie and then Anidaso at temperature 110°C. Moreover, the results revealed that, at temperature 115°C Nangbaar recorded the best significant ($p<0.01$)

fat content value compared to Quarshie that had the worst fat content value. Nangbaar was 2.00 and 2.94 higher in fat content than Quarshie and Anidaso respectively. At temperature 120^{o}C, Nangbaar again recorded the best fat content value relative to Anidaso which recorded the worst.

With respect to protein, Anidaso recorded the highest significant ($p<0.01$) protein values at the processing temperatures, 110^{o}C and 115^{o}C. No significant ($p<0.01$) difference was recorded between Anidaso and Quarshie at processing temperature 120^{o}C.

Regarding ash content, the highest and lowest significant ($p<0.01$) ash content values were recorded by Anidaso and Nangbaar respectively for the three different processing temperatures (Table 4.2c.). The results also demonstrated that, higher significant ($p<0.01$) moisture content values were recorded by Nangbaar while Anidaso and Quarshie recorded the same lower moisture values for the three different processing temperatures.

Furthermore, the effect of variety and processing temperature on the proximate composition of carbohydrate recorded significant ($p<0.01$) difference. It was observed that Quarshie recorded the highest carbohydrate content whiles Nangbaar recorded the lowest carbohydrate content at the respective temperatures. However, significant differences were not recorded between Anidaso and Nangbaar at the processing temperatures, 110^{o}C and 120^{o}C.

Variety*Temperature **PROXIMATE COMPOSITION**

Table 4.2(c):

	Fat	Protein	Ash	Moisture	CHO
Anidaso*110ºC	0.91g	37.24a	4.07c	3.89c	53.91e
Nangbaar*110ºC	3.16b	32.72c	3.49d	5.42ab	55.27e
Quarshie*110ºC	1.42f	33.67b	1.44f	4.34c	59.15cd
Anidaso*115ºC	0.53h	33.52b	6.54a	4.55bc	54.87e
Nangbaar*115ºC	3.47a	29.24d	3.13d	6.15a	57.53d
Quarshie*115ºC	1.47f	27.47e	1.74f	4.90bc	64.43a
Anidaso*120ºC	2.23d	29.50d	4.59b	4.57bc	59.94bc
Nangbaar*120ºC	2.88c	27.30e	2.47e	5.97a	61.42b
Quarshie*120ºC	1.86e	29.31d	1.91f	4.48bc	63.10a
CV	4.55	1.02	6.27	9.06	1.19

Interaction effect of variety and processing temperature on proximate composition

CV = Co-efficient of variance. Means with the same letters within a column are not significantly different at 1% using L.S.D.

4.3 Effect of Variety and Processing Temperature on Shelf-life of Soymilk From Table 4.3, the three different soybean varieties did not significantly ($p<0.01$) influenced the shelf-life of soymilk during the study. However, Anidaso recorded the highest shelf-life value relative to Quarshie which recorded the lowest value (Table 4.).

Processing temperature significantly ($p<0.01$) affected the shelf-life of soymilk as was observed. The highest and lowest significant ($p<0.01$) temperature values on shelf-life of

soymilk was recorded at 115^{o}C and 120^{o}C. Significant differences were not recorded between temperatures 110^{o}C and 115^{o}C ($p<0.01$).

The interaction between variety and temperature on soymilk shelf-life was not significant ($p<0.01$) at 110^{o}C. The interaction results at 110^{o}C demonstrated that, Anidaso and Quarshie recorded similar shelf-life values. Moreover, the shelf-life of soymilk was not significantly ($p<0.01$) influenced at 115^{o}C. At 120^{o}C, the highest and lowest shelf-life value of soymilk was recorded by Anidaso and Quarshie respectively. No significant ($p<0.01$) differences was recorded between Anidaso and Nangbaar as well as Nangbaar and Quarshie.

Table 4.3: Effect of variety and processing temperature on shelf-life of soymilk

VARIETY	PROCESSING TEMPERATURE			MEAN
	110^{o}C	115^{o}C	120^{o}C	
Anidaso	5.00a	4.67a	2.33b	4.00a
Nangbaar	4.67a	4.33a	1.67bc	3.56a
Quarshie	5.00a	4.67a	1.00c	3.56a
MEAN	4.89a	4.56a	1.67b	
CV	14.81	14.81	14.81	14.81

CV = Co-efficient of variance. Means with the same letters within a column are not significantly different at 1% using L.S.D.

CHAPTER FIVE

5.0 DISCUSSION

5.1 Effect of Variety and Processing Temperature on Yield of Soymilk

The varieties of soybean such as Anidaso, Nangbaar and Quarshie have little effects on the yield of soymilk. The present study revealed that variety and temperature significantly influenced the yield of soymilk (Table 4.1). Nangbaar variety of soybean yielded the highest significant amount of soymilk, followed by Anidaso and then the Quarshie variety. This may be partly due to different genotypes of the soybeans coupled with the different temperatures. This is not different from the work of Gesinde *et al.* (2008) who identified significant differences in the effect of variety on the yield of soymilk. The results also demonstrated that, processing temperature of 110^{o}C produced the highest significant soymilk relatively to the processing temperature, 115^{o}C that recorded the lowest. This may be caused by the differences in the soybean varieties and the temperature levels. This is different from the research conducted by Bhardwaj *et al*. (1999), who reported that soybean genotype significantly affected the soymilk parameters except the yield. The authors also explained that soymilk yield is not correlated with seed characteristics and processing temperature.

Within the temperature range used in the experiment, soymilk yield was affected differently. The lowest temperature gave the highest yield of soymilk. This may be partly due to the rate of evaporation which increases with high temperature (Wilson and Erikson, 1995), resulting in the decrease of yield at high processing temperature. So for higher economic gains, lower processing temperature is necessary.

Regarding the effect of a combination of variety of soybean and temperature, it was realized that Nangbaar variety which gave the highest yield of soymilk produced even higher amount of soymilk when combined with the lowest processing temperature. This shows that it may be advisable to combine these two factors when producing soymilk.

The least soymilk yield was produced by the combination of Quarshie at temperature 120^{o}C. This may also partly due to the high rate of evaporation at the higher temperature (Wilson and Erikson, 1995). This shows that when looking at which combination to use for soymilk production, Quarshie and higher temperatures should not be considered.

Even though Nangbaar is seen to give the best yield of soymilk, combining it with higher temperature produced lower yields than Anidaso at lower temperature. From the study, the best soybean variety and the best processing temperature of producing high yielding soymilk are the Nangbaar and 110^{o}C respectively.

5.2 Varietal Effect on Proximate Composition

Research available indicate that various varieties of soybean differently influence proximate composition. The present study is not different from the research carried out by by Khatib and Aramount (2002) who identified variety as one of the factors affecting soymilk quality. The present work revealed that, Nangbaar recorded higher significant fat content compared to Quarshie that provided the least fat content. This may be attributed to the different varieties of soybean used to conduct the research as well as the environment that might have influenced the differences in fat content.

Considering the protein composition which is a very important component of soybean, Anidaso recorded the highest significant protein content, followed by Quarshie and then Nangbaar. This may be attributed to the varietal difference of the soybean. Murphy *et al.* (2006), reported that the ratio of proteins varies among varieties and can affect the quality of soymilk. Zhang *et al*. (1991), further reported that soybeans are widely known as a high quality, cholesterol free, low-cost protein source and are principally vegetable proteins globally.

Anidaso recorded the highest ash content, relative to Nangbaar that recorded the lowest ash content. This could be due to more mineral being extracted from Anidaso soybean variety compared to less mineral that might have been extracted from Nangbaar (Onuorah *et al.*, 2007).

The moisture content recorded in the study was significantly between 5.85 % to 4.57 % by Nangbaar and Quarshie respectively. The low moisture contents recorded might be attributed to the fact that the soybean varieties were obtained at a low moisture content for the study. However the study by Gesinde *et al*. (2008) recorded high average moisture content (91.24) which are different from the average moisture content (4.92) of the present study.

The carbohydrate content recorded in the study was high and significant. Quarshie recorded the highest significant composition of carbohydrate (62.23) whiles Anidaso recorded the lowest (56.24). This may be as a result of the different varieties of soybean

used. This is different from the findings by Gesinde *et al.* (2008) who reported a very low carbohydrate content (2.26) in their research work.

5.1 Processing Temperature Effect on Proximate Composition

Heat is one of the modified soymilk extraction methods (Iwe, 2003). Egbo (2012), reported that thermal processing has an effect on the quality of soymilk with particular reference to proximate composition. The effects of the various temperature levels on fat composition revealed that, the highest significant fat content was obtained at 120^{o}C compared to the processing temperatures, 110^{o}C and 115^{o}C that recorded the same lowest fat content values (Table 4.2b). This trend may be due to the different processing temperatures that were used for the processing as well as the different soybean varieties used in the study. This follows that soy fat which is of high quality and cholesterol-free is higher when soymilk is processed at higher temperature.

The results obtained in the current study also revealed that, temperature was inversely proportional to protein content. The lowest temperature level had the highest amount of protein composition (28.70) followed by the second lowest and then the highest temperature level. This is not different from research work done by Sara (2011) who indicated that the structure of proteins changes with heat. So protein is denatured at high temperature, reducing the quality of soymilk.

Processing temperature of 115^{o}C produced the highest significant moisture content (5.20) compared to 110^{o}C that recorded the lowest moisture content (4.55). So vitamins, minerals and food materials contained in the moisture and giving distinctive flavour are higher at the processing temperature of 115^{o}C.

Higher temperature levels give higher carbohydrate composition (61.49) and low temperature levels also give low carbohydrate composition (56.11). So energy provision is higher at higher processing temperatures.

5.2.2 Interaction Effect of Variety and Processing Temperature on Proximate Composition

Considering the combined effects of processing temperature and variety of soymilk on the various compositions, varied effects were observed example, Nangbaar at a processing temperature of 115^{o}C produced the highest fat content. Even though processing Nangbaar at 120^{o}C individually gave the high fat contents at their respective comparisons, it was realized that Nangbaar at 115^{o}C, had the highest fat content (3.47) as compared to the other treatments. The lowest fat content was realized with Anidaso at 115^{o}C (0.53). So processing Nangbaar at 115^{o}C provides high content of fat than the rest of the interactions. The results therefore demonstrated that, Nangbaar exhibited a specific trend by recording the highest significant fat content values for the different temperatures throughout the study (Table 4.2b.)

Again the combination of the variety and processing temperature to assess the composition is very crucial because, combining the two factors has significantly increased the protein content than when only variety of soybean or processing temperature was used. Therefore the interaction effect of both variety and processing temperature on the protein composition cannot be over emphasized.

Also Anidaso at 115^{o}C has almost doubled the ash content as compared to when only variety or processing temperature was used. The moisture content also increased with

Nangbaar at 115ºC (6.15). Finally Quarshie at 115ºC gave the highest carbohydrate content (64.43). Even though 120ºC gave the best carbohydrate content (61.49) when we looked at the main effect of processing temperature on the composition, combining it with Quarshie only gave the second highest of carbohydrate composition 63.10).

5.3 Effect of Variety and Processing Temperature on Shelf-life of Soymilk

Fresh soymilk has a very short shelf-life which limits consumption to areas close the production site (Kwok *et al.*, 1999). The assessment of spoilage of soymilk for the various varieties of soybean showed that, Anidaso recorded a shorter shelf-life (4.00) compared to Nangbaar and Quarshie. This may be due to the differences in the pH content of the various varieties as it was suggested by Adebayo-Tayo *et al.* (2009).

Regarding how processing temperature affects the shelf-life of the soymilk, the highest processing temperature of 120ºC increased the shelf-life of the VitaGoat-processed soymilk. This follows that higher processing temperature has the potential of destroying micro-organisms that cause spoilage (Kwok *et al.*, 1999).

Assessing the combined effect of variety of soybean and temperature levels, a combination of Anidaso at 115ºC, and Quarshie at 115ºC had the shortest soymilk shelf-life (4.67) whereas Quarshie at 120ºC reported the longest shelf-life of a soymilk (1.00). Nangbaar soymilk at 120ºC showed a longer shelf-life of the soymilk. Kwok *et al* (1999) reported that thermal processing can improve the microbial safety and extend the shelf-life of soymilk as it inactivates many spoilage organisms.

Though using a temperature level of 120ºC gave a better shelf-life, combining this processing temperature with Quarshie will yield a better shelf-life of the soymilk and hence reduce its spoilage (Kwok *et al,* 1999).

CHAPTER SIX

6.0 SUMMARY OF FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

Summary of Findings

The study found that there was significant differences among the varieties and within the temperature range used in producing soymilk and since there was interaction, indicates that variety and processing temperature have significant effect on the yield of soymilk.

It was established that processing soymilk at low temperature gave more yield and high quality and even for higher economic gains. At higher processing temperature, there was a lower quality but longer shelf-life. So it is best to process soymilk at lower temperature when there is good cold chain system or refrigeration but in the wake of power outages it good to process at higher temperature even though some amount of quality will be sacrificed.

Conclusions

Based on the findings of the study, it can be concluded that:

1. The best variety for producing high yielding soymilk was the Nangbaar which yielded 16.9 Litres of soymilk as against 16.07 Litres and 15.17 Litres yielded by Anidaso and Quarshie respectively.
2. Processing temperature of 110^{o}C yielded the largest quantity of soymilk (16.58Litres) as compared to 16 Litres and 15 Litres produced at the temperatures 115^{o}C and 120^{o}C respectively.

3. The interaction of Anidaso and 110^{o}C gave the highest yield of soymilk (17.43 Litres) than the rest of the interaction between the varieties and the temperatures.
4. . Nangbaar had the highest contents of fat (3.17%) and moisture (4.33%), Anidaso also had the highest protein content (33.42%) and ash (5.06%) while Quarshie had the highest content of carbohydrate (62.23%).
5. Processing temperature of 120^{o}C gave the highest content of fat (2.32%) and carbohydrate content (61.49%), 110^{o}C gave the highest content of protein (34.54%) while 115^{o}C gave the highest ash content (3.80%) and moisture content (5.20%).
6. The interaction of Nangbaar by 115^{o}C had the highest fat content (3.47%) and moisture (6.15%), Anidaso by 110^{o}C had the highest protein content (37.24%), Anidaso by 115^{o}C had the highest content of ash (6.54%), Nangbaar and 115^{o}C had the highest moisture (6.15%) while Quarshie by 115^{o}C had the highest carbohydrate content (64.43%).
7. The shelf-life of Nangbaar and Quarshie were found to be longer as small percentage (3.56%) spoiled after three weeks as compared to Anidaso which had 4.00% spoilt.
8. The processing temperature of 120^{o}C gave the longest shelf-life of soymilk as the least percentage (1.6%) spoiled. Meanwhile, Quarshie by 120^{o}C interactions had the longest shelf-life of soymilk since the interaction gave the least percentage (1.00%) of the samples of soymilk kept for three weeks spoilt as compared to the rest of the interactions between the varieties and the temperatures.

Recommendations

Based on the research undertaken, the following recommendations are made:

1. For higher economic gains, Nangbaar at 110^{o}C is recommended as it recorded the highest yield of soymilk (17.43%).

2. The interaction of Quarshie by 120^{o}C is recommended for producing the quality soymilk as it gave the highest percentage of protein which is the most important composition of soybean. The same interaction gave the least fat composition (0.91%).

3. For a longer shelf-life, processing Quarshie at 120^{o}C is recommended for giving the least percentage of spoilage (1.00%) of the soymilk samples kept for three weeks.

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APPENDICES

Appendix 1 **a**

b

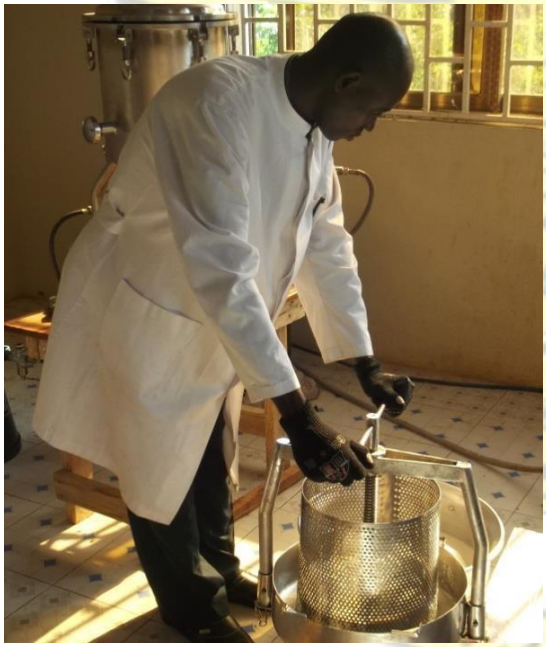
c

Appendix 2

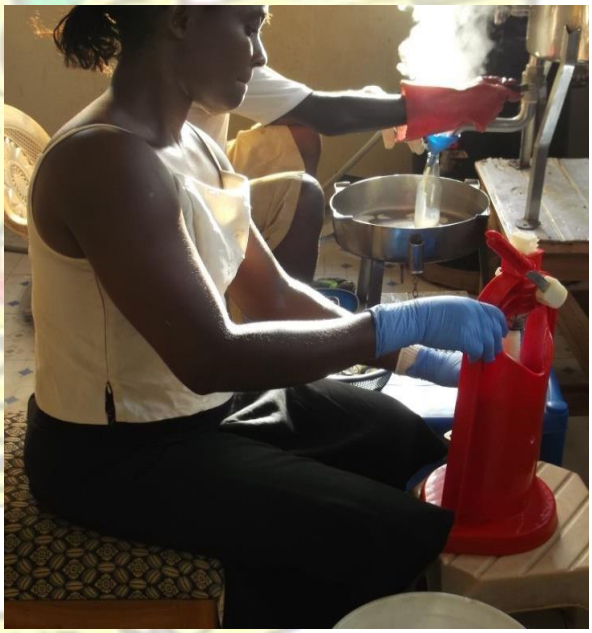
a

b

c



d



Appendix

a

b

Appendix 4

YIELD ANALYSIS

Student Edition of Statistix 9.0

LSD All-Pairwise Comparisons Test of YIELD for VARIETY

VARIETY	Mean	Homogeneous Groups
Nangbaar	16.900	A
Anidaso	16.067	B
Quarshie	15.167	C

Alpha 0.01 Standard Error for Comparison 0.1349
Critical T Value 2.921 Critical Value for Comparison 0.3941
Error term used: REPS*VARIETY*TEMP, 16 DF
All 3 means are significantly different from one another.

LSD All-Pairwise Comparisons Test of YIELD for TEMP

TEMP	Mean	Homogeneous Groups
110	16.578	A
115	16.067	B
120	15.489	C

Alpha 0.01 Standard Error for Comparison 0.1349
Critical T Value 2.921 Critical Value for Comparison 0.3941
Error term used: REPS*VARIETY*TEMP, 16 DF
All 3 means are significantly different from one another.

LSD All-Pairwise Comparisons Test of YIELD for VARIETY*TEMP

VARIETY	TEMP	Mean	Homogeneous Groups
Nangbaar	110	17.433	A
Nangbaar	115	17.000	AB
Anidaso	110	16.700	BC
Nangbaar	120	16.267	CD
Anidaso	115	16.067	CDE
Quarshie	110	15.600	DEF
Anidaso	120	15.433	EFG
Quarshie	115	15.133	FG
Quarshie	120	14.767	G

Alpha 0.01 Standard Error for Comparison 0.2337
Critical T Value 2.921 Critical Value for Comparison 0.6827
Error term used: REPS*VARIETY*TEMP, 16 DF There
are 7 groups (A, B, etc.) in which the means are
not significantly different from one another.

Analysis of Variance Table for YIELD

Source	DF	SS	MS	F	P
REPS	2	0.0089	0.00444		
VARIETY	2	13.5267	6.76333	82.54	0.0000
TEMP	2	5.3422	2.67111	32.60	0.0000
VARIETY*TEMP	4	0.1978	0.04944	0.60	0.6658
Error	16	1.3111	0.08194		
Total	26	20.3867			

Grand Mean 16.044 CV 1.78

ASH ANALYSIS

Student Edition of Statistix 9.0

LSD All-Pairwise Comparisons Test of V005 for V002*V004

V002	V004	Mean	Homogeneous Groups
Anidaso	115	6.5367	A
Anidaso	120	4.5900	B
Anidaso	110	4.0667	C
Nangbaar	110	3.4867	D
Nangbaar	115	3.1267	D
Nangbaar	120	2.4667	E
Quarshie	120	1.9067	F
Quarshie	115	1.7400	F
Quarshie	110	1.4400	F

Alpha 0.01 Standard Error for Comparison 0.1670
Critical T Value 2.921 Critical Value for Comparison 0.4878
Error term used: V001*V002*V004, 16 DF
There are 6 groups (A, B, etc.) in which the means are
not significantly different from one another.

LSD All-Pairwise Comparisons Test of V005 for V002

V002	Mean	Homogeneous Groups
Anidaso	5.0644	A
Nangbaar	3.0267	B Quarshie
1.6956	C	

Alpha 0.01 Standard Error for Comparison 0.0964
Critical T Value 2.921 Critical Value for Comparison 0.2816
Error term used: V001*V002*V004, 16 DF
All 3 means are significantly different from one another.

LSD All-Pairwise Comparisons Test of V005 for V004

V004	Mean	Homogeneous Groups
115	3.8011	A

```
 110  2.9978   B
 120  2.9878   B

Alpha              0.01     Standard Error for Comparison  0.0964
Critical T Value  2.921     Critical Value for Comparison  0.2816
Error term used: V001*V002*V004, 16 DF There are
2 groups (A and B) in which the means are not
significantly different from one another.
```

Analysis of Variance Table for ASH

Source	DF	SS	MS	F	P
REPS	2	3.92087	1.96043		
VARIETY	2	51.82142	25.91071	44.98	0.0000
TEMP	2	8.18458	2.04614	594.43	0.0000
VARIETY*TEMP	4	0.1978	0.04359	0.60	0.6658
Error	16	1.3111	0.08194		
Total	26	64.71147			

Grand Mean 16.044 CV 1.78

FAT COMPOSITION

Student Edition of Statistix 9.0

LSD All-Pairwise Comparisons Test of V005 for V002

V002	Mean	Homogeneous Groups
Nangbaar	3.1689	A
Quarshie	1.5811	B
Anidaso	1.2222	C

```
Alpha              0.01     Standard Error for Comparison  0.0427
Critical T Value  2.921     Critical Value for Comparison  0.1248
Error term used: V001*V002*V004, 16 DF
All 3 means are significantly different from one another.
```

LSD All-Pairwise Comparisons Test of V005 for V004

V004	Mean	Homogeneous Groups
120	2.3211	A
110	1.8289	B
115	1.8222	B

```
Alpha              0.01     Standard Error for Comparison  0.0427
Critical T Value  2.921     Critical Value for Comparison  0.1248
Error term used: V001*V002*V004, 16 DF There are
2 groups (A and B) in which the means are not
significantly different from one another.
```

LSD All-Pairwise Comparisons Test of V005 for V002*V004

V002	V004	Mean	Homogeneous Groups
Nangbaar	115	3.4700	A
Nangbaar	110	3.1600	B
Nangbaar	120	2.8767	C
Anidaso	120	2.2267	D
Quarshie	120	1.8600	E
Quarshie	115	1.4667	F
Quarshie	110	1.4167	F
Anidaso	110	0.9100	G

Anidaso 115 0.5300 H

Alpha 0.01 Standard Error for Comparison 0.0740
Critical T Value 2.921 Critical Value for Comparison 0.2161
Error term used: V001*V002*V004, 16 DF
There are 8 groups (A, B, etc.) in which the means
are not significantly different from one another.

Analysis of Variance Table for FAT

Source	DF	SS	MS	F	P
REPS	2	0.0117	0.00583		
VARIETY	2	19.3181	9.65903	1176.00	0.0000
TEMP	2	1.4737	0.73683	89.71	0.0000
VARIETY*TEMP	4	4.1652	1.04130	126.78	0.0000
Error	16	0.1314	0.00821		
Total	26	25.1000			

Grand Mean 1.9907 CV 6.55

MOISTURE COMPOSITION

Student Edition of Statistix 9.0

LSD All-Pairwise Comparisons Test of V005 for V002

V002	Mean	Homogeneous Groups
Nangbaar	5.8456	A
Quarshie	4.5722	B
Anidaso	4.3333	B

Alpha 0.01 Standard Error for Comparison 0.2099
Critical T Value 2.921 Critical Value for Comparison 0.6131
Error term used: V001*V002*V004, 16 DF There are
2 groups (A and B) in which the means are not
significantly different from one another.

LSD All-Pairwise Comparisons Test of V005 for V004

V004	Mean	Homogeneous Groups
115	5.1978	A
120	5.0067	AB
110	4.5467	B

Alpha 0.01 Standard Error for Comparison 0.2099
Critical T Value 2.921 Critical Value for Comparison 0.6131
Error term used: V001*V002*V004, 16 DF There are
2 groups (A and B) in which the means are not
significantly different from one another.

LSD All-Pairwise Comparisons Test of V005 for V002*V004

V002	V004	Mean	Homogeneous Groups
Nangbaar	115	6.1467	A
Nangbaar	120	5.9733	A

Nangbaar	110	5.4167	AB
Quarshie	115	4.9000	BC
Anidaso	120	4.5667	BC
Anidaso	115	4.5467	BC
Quarshie	120	4.4800	BC
Quarshie	110	4.3367	C
Anidaso	110	3.8867	C

Alpha 0.01 Standard Error for Comparison 0.3636
Critical T Value 2.921 Critical Value for Comparison 1.0619
Error term used: V001*V002*V004, 16 DF
There are 3 groups (A, B, etc.) in which the means are
not significantly different from one another.

Analysis of Variance Table for MOISTURE

Source	DF	SS	MS	F	P
REPS	2	0.0365	0.01823		
VARIETY	2	11.8958	5.94789	30.00	0.0000
TEMP	2	2.0162	1.00810	5.08	0.0195
VARIETY*TEMP	4	0.2693	0.06733	0.34	0.8473
Error	16	3.1726	0.19829		
Total	26	17.3904			

Grand Mean 4.9170 CV 9.06

PROTEIN ANALYSIS

Student Edition of Statistix 9.0

LSD All-Pairwise Comparisons Test of V005 for V004

V004	**Mean**	**Homogeneous Groups**
110	34.539	A
115	30.076	B
120	28.702	C

Alpha	0.01	Standard Error for Comparison	0.1501
Critical T Value	2.921	Critical Value for Comparison	0.4385

Error term used: V001*V002*V004, 16 DF
All 3 means are significantly different from one another.

LSD All-Pairwise Comparisons Test of V005 for V002

V002	**Mean**	**Homogeneous Groups**
Anidaso	33.419	A
Quarshie	30.146	B
Nangbaar	29.752	B

Alpha	0.01	Standard Error for Comparison	0.1501
Critical T Value	2.921	Critical Value for Comparison	0.4385

Error term used: V001*V002*V004, 16 DF There are
2 groups (A and B) in which the means are not
significantly different from one another.

LSD All-Pairwise Comparisons Test of V005 for V002*V004

V002	V004	Mean	Homogeneous Groups
Anidaso	110	37.237	A
Quarshie	110	33.660	B
Anidaso	115	33.520	B
Nangbaar	110	32.720	C
Anidaso	120	29.500	D
Quarshie	120	29.307	D
Nangbaar	115	29.237	D
Quarshie	115	27.470	E
Nangbaar	120	27.300	E

Alpha 0.01 Standard Error for Comparison 0.2600
Critical T Value 2.921 Critical Value for Comparison 0.7595
Error term used: V001*V002*V004, 16 DF
There are 5 groups (A, B, etc.) in which the means
are not significantly different from one another.

Analysis of Variance Table for PROTEIN

Source	DF	SS	MS	F	P
REPS	2	0.384	0.1921		
VARIETY	2	72.942	36.4708	359.60	0.0000
TEMP	2	167.622	83.8111	826.38	0.0000
VARIETY*TEMP	4	28.109	7.0274	69.29	0.0000
Error	16	1.623	0.1014		
Total	26	270.680			

Grand Mean 31.106 CV 1.02

CARBOHYDRATE ANALYSIS

Student Edition of Statistix 9.0

LSD All-Pairwise Comparisons Test of V005 for V002

V002	Mean	Homogeneous Groups
Quarshie	62.226	A
Nangbaar	58.072	B
Anidaso	56.238	C

Alpha 0.01 Standard Error for Comparison 0.3304
Critical T Value 2.921 Critical Value for Comparison 0.9651
Error term used: V001*V002*V004, 16 DF
All 3 means are significantly different from one another.

LSD All-Pairwise Comparisons Test of V005 for V004

V004	Mean	Homogeneous Groups
120	61.486	A
115	58.941	B
110	56.109	C

Alpha 0.01 Standard Error for Comparison 0.3304
Critical T Value 2.921 Critical Value for Comparison 0.9651
Error term used: V001*V002*V004, 16 DF

All 3 means are significantly different from one another.

LSD All-Pairwise Comparisons Test of V005 for V002*V004

V002	V004	Mean	Homogeneous Groups
Quarshie	115	64.427	A
Quarshie	120	63.100	A
Nangbaar	120	61.420	B
Anidaso	120	59.937	BC
Quarshie	110	59.150	CD
Nangbaar	115	57.527	D
Nangbaar	110	55.270	E
Anidaso	115	54.870	E
Anidaso	110	53.907	E

Alpha 0.01 Standard Error for Comparison 0.5723
Critical T Value 2.921 Critical Value for Comparison 1.6716
Error term used: V001*V002*V004, 16 DF
There are 5 groups (A, B, etc.) in which the means are
not significantly different from one another.

Analysis of Variance Table for CARBOHYDRATE

Source	DF	SS	MS	F	P
REPS	2	0.347	0.1734		
VARIETY	2	169.407	84.7033	172.40	0.0000
TEMP	2	130.213	65.1063	132.52	0.0000
VARIETY*TEMP	4	36.026	9.0065	18.33	0.0000
Error	16	7.861	0.4913		
Total	26	3433.583			

Grand Mean 58.845 CV 1.19

SHELF-LIFE ANALYSIS

Student Edition of Statistix 9.0

LSD All-Pairwise Comparisons Test of V004 for V002

V002	Mean	Homogeneous Groups
Anidaso	4.0000	A
Nangbaar	3.5556	A
Quarshie	3.5556	A

Alpha 0.01 Standard Error for Comparison 0.2586
Critical T Value 2.921 Critical Value for Comparison 0.7553
Error term used: V001*V002*V003, 16 DF
There are no significant pairwise differences among the means.

LSD All-Pairwise Comparisons Test of V004 for V003

V003	Mean	Homogeneous Groups
110	4.8889	A
115	4.5556	A

120 1.6667 B

Alpha 0.01 Standard Error for Comparison 0.2586
Critical T Value 2.921 Critical Value for Comparison 0.7553
Error term used: V001*V002*V003, 16 DF There are
2 groups (A and B) in which the means are not
significantly different from one another.

LSD All-Pairwise Comparisons Test of V004 for V002*V003

V002	V003	Mean	Homogeneous Groups
Anidaso	110	5.0000	A
Quarshie	110	5.0000	A
Anidaso	115	4.6667	A
Nangbaar	110	4.6667	A
Quarshie	115	4.6667	A
Nangbaar	115	4.3333	A
Anidaso	120	2.3333	B Nangbaar
120	1.6667	BC	
Quarshie	120	1.0000	C

Alpha 0.01 Standard Error for Comparison 0.4479
Critical T Value 2.921 Critical Value for Comparison 1.3082
Error term used: V001*V002*V003, 16 DF
There are 3 groups (A, B, etc.) in which the means are
not significantly different from one another.

Analysis of Variance Table for SHELF-LIFE

Source	DF	SS	MS	F	P
REPS	2	1.1852	0.5926		
VARIETY	2	1.1852	0.5926	1.97	0.1720
TEMP	2	56.5185	28.2593	93.91	0.0000
VARIETY*TEMP	4	1.9259	0.4815	1.60	0.2226
Error	16	4.8148	0.3009		
Total	26	65.6296			

Grand Mean 3.7037 CV 14.81