MODIFICATION AND PERFORMANCE EVALUATION OF A COTTAGE YOGURT PRODUCTION PLANT

BY

ADEBAYO JOEL OMONIYI

MATRIC. NO. 97/ 5896 EA

BEING A FINAL YEAR PROJECT SUBMITTED TO THE DEPARTMENT OF AGRICULTURAL ENGINEERING, FEDERAL UNIVERSITY OF TECHNOLOGY,

MINNA, NIGER STATE.

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AGRICULTURAL ENGINEERING
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CERTIFICATION

This is to certify that this Project was carried out by **Adebayo Joel Omoniyi** in Agricultural Engineering Department, Federal University of Technology, Minna, Niger State.

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DEDICATION

This project work is dedicated to the Most High God and to my Late Father, **Mr. Adebayo Ezekiel Aguntasolo**.

ACKNOWLEDGEMENT

With all my heart, I express my gratitude to God Almighty for his provisions and divine guidance on me during the course of carrying out the project work.

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ABSTRACT

This work presents modification and performance evaluation of an existing cottage yogurt production plant in the Department of Agricultural Engineering for pasteurization, homogenization and production efficiency and the palatability of the yogurt produced. The plant has a capacity of producing 25 litres of yogurt per batch. Yogurt is a semi-fermented milk product, yogurt was produced by heating $0.0085m^3$ of raw milk to 85^oC for 30 minutes (pasteurization) after which the heated milk was transferred from the milk tank to the cooling tank with the aid of a centrifugal pump (Homogenization). In the cooling tank, the temperature was cooled to 44^oC and later transferred back to the milk tank, here in the milk tank. 0.43kg sugar, 0.082kg of stabilizer, 10g of starter culture were added and stirred for 3 minutes for even distribution. The temperature of 44^oC was kept constant for 4 hours (incubation) after which the yogurt produce was cooled to 22^oC in a cooling tank. The result of the tests carried out on the raw milk, heated milk (pasteurized milk) and the yogurt gives a pH of 5.78, 6.1, 3.50 for raw milk, pasteurized milk and yogurt respectively and that of the microbial analysis was also stated. The yogurt production plant has a production time of 4.6 hours.

CHAPTER ONE

INTRODUCTION

Yogurt is a semi-solid fermented milk product, which originated centuries ago in Bulgaria. Its popularity has grown and is now consumed in most parts of the world. Although the consistency, flavor and aroma may vary from one region to another, the basic ingredients and manufacturing are essentially consistent. (Dairy science and technology, University of Guelph, 1999)

It is produced by heating milk (fresh or slurry) to a temperature of 63 °C. It is then held for 15 to 30 minutes; cooled to 43° C, inoculated with starter cultures and incubated at the same temperature for a minimum of three (3) hours.

Milk, the major raw material used in yogurt production has been identified as a source of nutrients for man. As a food product , it provides animals with new tissues and energy to do work. Milk can be consumed directly or indirectly. Prior to its consumption, milk is passed through various stages of handling and processing. During these stages pathogenic agent from the handler, the handling equipment or even the environment in which milk is handled could infect it. Milk is usually converted into cheese, ice cream or yogurt. In its direct form, milk is pasteurized, skimmed, or condensed.(Harper,1976)

Perhaps due to awareness that in developing nations, human diets are deficient in animal protein, or simply due to appellation, the consumption of milk (particularly in its converted form) has been on the increase in recent times in Nigeria (Ajisegiri, 1993). This development saw the advent of small-scale producers of yogurt and other allied product of milk. Consequent upon this development, there was an increase in the contamination of milk by the handler, equipment, and environment because milk has been identify as an ideal medium for bacteria proliferation. To

stem the side effects of the contamination on human health, it has become pertinent to evaluate the performance of the constructed machine and carry out the palatability test on the produced yogurt.

This will inadvertently increase the utilization of milk resources in Nigeria and ensure proper hygiene in the local production of yogurt. (Upahi, 2000)

1.1. Statement of the Problem

Though a food substance, yogurt is a substrate for microbial growth. The sharp drop in Nigeria national economy had brought with it a number of disorientation. The low level of personal income in Nigeria forced many to go for goods that are affordable only without consideration for the quality level of the product. Yogurt production in Nigeria used to be done by the organized industries. The drop in the national economy resulted in the high price of yogurt which had become an accepted refreshing drink among Nigerians. This therefore encouraged the small-scale producers of yogurt. Most of these household producers did not and still do not keep to the recommended hygiene for the processing of milk and milk products. Almost every operation in the production process gives room for contact between the milk and the bare bodies of the producer(s). This coupled with the fact that the equipment used are for short of the requirements for food processing and the fact that these equipment are not pathogenically free, makes the yogurt produced from them unsafe for human consumption.

1.2 Project Objectives

This project has the following specific objectives:

(a) To carry out modification and to evaluate the performance of the existing cottage yogurt production plant for pasteurization, homogenization and for yogurt production.

(b) To evaluate the palatability of the yogurt produced.

1.3. Scope of the Project

This work entails carrying out performance test on the existing yogurt production plant in the Department of Agricultural Engineering and evaluating the palatability of the product.

1.4. Limitations

Production of yogurt is best with fresh cattle milk. But the 'Cattle Fulani' move about with the cattle and milk such cows at different stations. This places a limitation on constant supply of fresh milk. There are few organized ranches and many of such ranches do not have pasteurizing equipment to prolong the life of fresh milk. Where fresh milk is obtainable, it has to be processed immediately since milk is a highly perishable product. Also, as fresh milk production is not ensured all the year round, powdered milk can be used for producing yogurt. (Upahi, 2000)

.5 Justification

Milk is a good medium for bacteria proliferation. It has also been known to be a good substrate for some micro-organisms which are responsible for some deadly diseases such as tuberculosis caused by micro-=bacterium Bovis Spp: Leptospiorsis caused by Brucella albortus etc (Banwart, 1989).

The productions of yogurt have traditionally been popular dietary items in Eastern Europe and the popularity in the UK has increased considerably in the past twenty five (25) years. Consumption has increased 10 fold from 0.4kg per person per year in 1966 to 4.1kg per person per year in 1989, according to the International Dairy Federation (IDF) Animal Statistics.

This project is part of such attempt to boost the production and consumption of yogurt in Nigeria and Africa as a whole.

Recently, the government of Nigeria, in order to protect the health of the citizens set up an agency, the National Agency for food and Drug Administration and Control (NAFDAC) to monitor and ensured that food and drug items produced in Nigeria are of health standards. In the bid to realize its mandate, the agency has, in place, modalities for checking and phasing out food items that are not produced at specified sanitary conditions. Most of the local producers of yogurt may fall into this category.

CHAPTER TWO

LITERATURE REVIEW

2.1. Milk as a Dairy Food Product

Two key words are found here. These are Dairy and Food.

By the new lexicon Webster's Encyclopedia Dictionary of English Language, "dairy" is defined as "part of farm given over" for the production of milk, cream, cheese etc. Similarly, food is defined as "any substance which by process of metabolism, a living organism can convert into fresh tissue, energy e.t.c. (Isaac, 1974).

From the foregoing, milk is both a dairy product and food. By definition, milk is a whole fluid that is secreted from the mammary glands of female mammals. This secretion is a natural process and the secreted fluid is a nature's provision as a complete food for every young animals (Harper, 1976; Ihekoronye and Ngoddy, 1985). Milk is not only an excellent food for young calves; it has become a valuable food for both human children and adults. It is an important source of animal protein and it is because of this importance of milk to human diet, that the food and Agricultural Organisation (FAO, 1989), stipulated a minimum per capital consumption, per year of 40kg for developing nations. Reports however reveal that this minimum level has not being met according to Ajisegiri (1993).

Milk, the major raw material for yogurt production, has been identified as one of the rich sources of nutrients for proper metabolic functioning of man, (Asibong, 1991). Milk can be consumed directly or indirectly. The indirect form of consuming milk as to convert it to it's allied forms such as Yogurt, Ice cream, cheese etc. In the Nigeria context, milk is much more consumed in it's converted form than its direct form. Directly, milk is pasteurized skimmed or

condensed and in this form, milk is taken as additives to beverages at breakfast tables or when beverages are taken as refreshments.

Milk, in it's converted form, is more often taken as a refreshing drink and the consumption cuts across all ages. The rate of consumption is growing at a fairly steady state. Though there are no formal statistical data to support this claim, reconnaissance survey of Cottage and Industrial Production agree with the submission. (Upahi, 2000)

At the early stage, production of yogurt was restricted to conventional dairy processing industries, which install machineries for this purpose. The cost of yogurt rose astronomically to pace with the rise in the cost of machineries caused by the dwindling value of the Naira. At this point, a 25cl of yogurt sold for N100 or more. There was accompanying reduction in demand.

This development created room for the springing up of cottage industries that were involved in the production and marketing of yogurt. Though the production technique by these emergency producers varies and deviate from standardized scientific procedure, it saw, a decline in the cost of yogurt by about 42%. This in turn brought about an attendant rise in the hot season, and this rise in demand and production has been on the increase since 1994. (Upahi, 2000)

This development in the yogurt industry signals a prospect for yogurt making machines designed for small-scale use. This will increase production, efficiency, reduce cost and drudgery. It will most importantly, ensure sanitation in the production of milk yogurt because according to Ajisegiri, (1993) "Milk is one of the most ideal media for bacteria proliferation".

2.2 Constituents of Milk

The constitution of milk varies according to the source that may be affected by the breed, nature of its food and the season during which lactation is had. The most important constituents

of milk are fat, protein (casein), lactose, and the minerals, collectively referred to as ash. Water is a major constituent taking about 88% of milk content. It serves as the solvent for colloidal system which milk is.

TABLE2:1 The composition of milk from the different sources:

Composition of milk according to source (%)

Source	Total solid %	Fat %	Casein %	Crude protein %	Lactose %	Ash %
Cow	12.60	3.80	2.78	3.35	4.75	0.70
Goat	13.18	4.24	2.80	3.70	4.51	0.78
Sheep	17.00	5.30	4.60	6.30	4.60	0.80
Buffalo	16.77	7.45	4.30	3.78	4.78	0.78
Woman	12.57	3.75	-	1.63	6.98	0.21

(Delia and Herbert, 1986)

2.3 Production of Yogurt

Yogurt (also spelled yoghurt) is a semi-solid fermented milk product, which originated centuries ago in Bulgaria. It's popularity has grown and is now consumed in most parts of the world. Although the consistency, and aroma may vary from one region to another, the basic ingredients and manufacturing are essentially consistent: (University of Guelph, 1999)

Low bacteria count

Free from antibiotics, sanitizing chemicals, mastitis milk, colostrums, and rancid milk no contamination by bacteriophages.

Other yogurt ingredients may include some or all of the following:

Other dairy products: Concentrated skim milk, nonfat dry milk, whey, lactose. These products are often used to increase the nonfat solid content.

Flavours

Fruit preparations: Including natural and artificial flavouring colour.

Starter Culture

The starter culture for most yogurt production in North America is a symbiotic blend of streptococcus salivarious subsp. Thermophilus (ST) and Lactobacillus delbrueckii subsp bulgaricus (LB). Although they can grow independently, the rate of acid production is much higher when used together than either of the two organisms grown individually. ST grows faster and produces both acid and carbondioxide. The formate and carbondioxide produced stimulates LB growth. On the other hand, the proteolytic activity of LB produces stimulatory peptides and amino acids for use by ST. These microorganisms are ultimately responsible for the formation of typical yogurt flavour and texture. The yogurt mixture coagulates during fermentation due to the drop in pH. The streptococci are responsible for the initial pH drop of the yogurt mix to approximately 5.0. The lactobacelli are responsible for a further decrease to pH 4.0. The following fermentation, products contribute to flavour: lactic acid, acetaldehyde, acetic acid, diacetyl. (University of Guelph, 1999)

Manufacturing Method

The milk is clarified and separated into cream and skim milk, then standardized to achieve the desired fat content. The various ingredients are then blended together in a mix tank-equipped with a powder fumed and an agitation system. The mixture is then pasteurized using a continuous plate heat exchanger for 30 minutes at 85°C or 10 minutes at 95°C. These heat treatments, which are much more secure than fluid milk pasteurization, are necessary to achieve the following:

. Produce a relatively sterile and conducive environment for the starter culture

. Denature and coagulate whey proteins to enhance the viscosity and texture.

The mix is then homogenized using high pressures of 2000-2500 psi. Besides thoroughly mixing the stabilizers and other ingredients homogenization also prevents creaming and wheying off during incubation and storage. Stability, consistency and body and enhanced by homogenization. Once the homogenized mix has cooled to an optimum growth temperature the yogurt starter culture is added.

A ratio of 1:1, ST to LB inoculation is added to the jacketed fermentation tank. A temperature of 43°C is maintained for 4-6 hour under quiescent (no agitation) conditions. This temperature is a compromise between the optimums for the two microorganisms (ST 39°C; LB 45°C). The tiltra-table acidity is carefully monitored until the TA is 0.85 to 0.90%. At this time the jacket is replaced with cool waters and agitation begins, both of which stop the fermentation. The coagulated product is cooled to 5-22°C, depending on the product. Fruit and flavour may be incorporated at this time, then packaged. The product is now cooled and stored at refrigeration temperatures (5°C) to slow down the physical chemical and microbiological degradation.

Yogurt Products

There are two types of plain yogurt:

Stirred style yogurt

Set style yogurt

The above description is essentially the manufacturing procedures for stirred style. In set style, the yogurt is packaged immediately after inoculation with the starter and is incubated in the packages. Other yogurt products include:

Fruit-on-the-bottom style:

Fruit mixture is layered at the bottom followed by inoculated yogurt, incubation incursion the sealed cups.

Soft-serve and hard pack frozen yogurt

Continental, French, and Swiss:

Stirred style yogurt with fruit preparation. (University of Guelph, 1999)

2.4. Milk handling and processing

As can be inferred from the foregoing reviews, milk is a highly perishable food item. It is for this reason that milk is not only desired to be handled hygienically but also processed promptly. Processing of food items involved treatments given to them in order to preserve them and prevent spoilage. Two major things are responsible for the spoilage of milk and these are the content and extent of content of microorganisms and the extent of chemical constituents and nature of the milk. Therefore to process milk is to seek to eliminate the micro organisms in milk or adjust their conditions of presence that will be suitable for safe keeping of the milk. These are aimed "inactivating the disease causing organisms and to prolong the shelf life of the milk product" (Ajisegiri, 1993).

The four ways of achieving these according to harper (1976) as cited by Ajisegiri (1993) are through the processes of homogenization. Sterilization, thermization and pasteurization. Of these methods, pasteurization has been identified as a very effective means of eliminating microbes without causing considerable damage to the milk nutrient particularly the protein (Isaac, 1971, Harderson, 1971).

Milk for the production of yogurt should comply with the following requirements, low bacteria counts, absence of pathogenic organisms, and absence or very low concentrations of various inhibitory substances which may find their way into milk, such as residues of antibiotics from the treatment of mastilis, residues of dairy sanitizers, e.t.c.

Processes Involved

- Clarification
- Standardization
- Pasteurization
- Homogenization
- Fermentation/Incubation
- Cooling
- Flavouring / Fruit
- Packaging
- Regulatory Aspects/Quality Control

Below is the flow chart for the production of Yogurt

FLOW LINE FOR YOGURT PRODUCTIONS (2 Stage pasteurization)

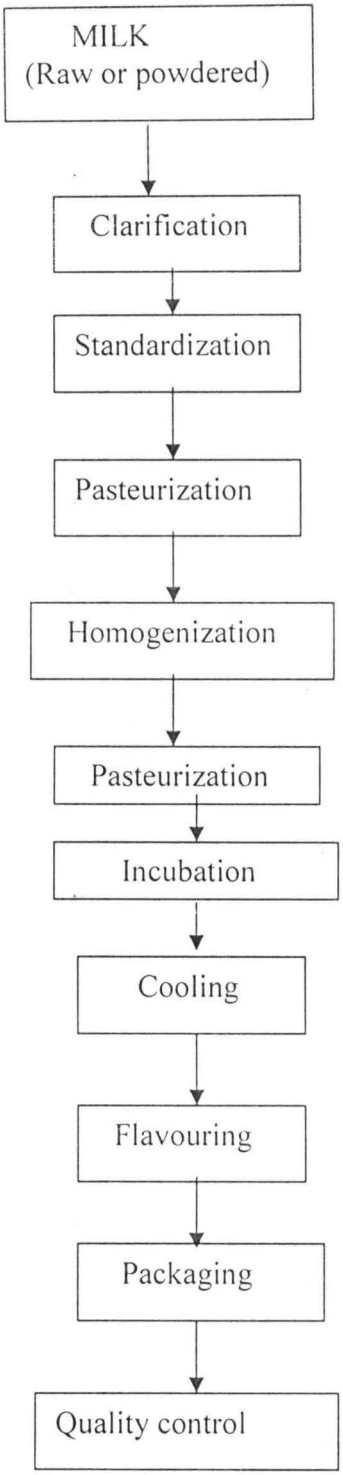


Fig 2.1 Flow line for yogurt production (2 stage pasteurization)

2.4.1 Clarification

Separation and clarification can be done at the same time in one centrifuge. Particles, which are denser than the continuous milk phase, are thrown back to the perimeter. The solids that collect in the centrifuge consist of diet, epithetial cells, leucocytes, corpuscles, bacteria sediment and sludge. The amount of solids that collect will vary, however, it must be removed from the centrifuge.

More modern centrifuges are self-cleaning allowing a continuous separation/clarification process. This type of centrifuge consists of a specially constructed bowl with pheripheral discharge slots. These slots are kept closed under pressure. With a momentary release of pressure, for about 0.15, the content of sediment space are evacuated. This can mean anywhere from 8 to 25 L are ejected at intervals of 60 mins. For one dairy, self cleaning translated to a loss of 50L/hr of milk. (University of Guelph, 1999)

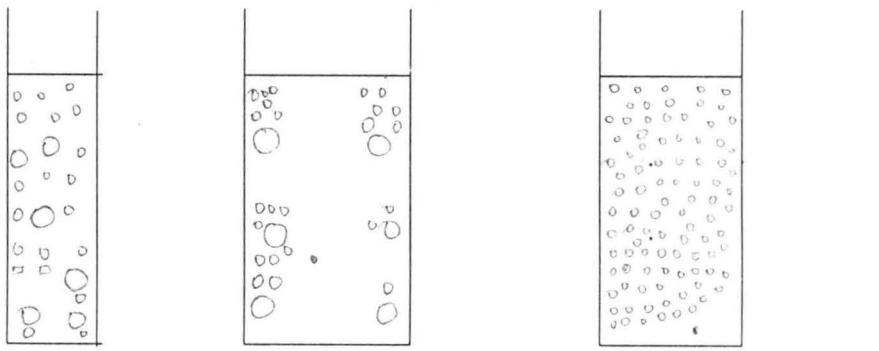
2.4.2.Standardization

The streams of skim and cream after separation must be recombined to a specified fat content. This can be done by adjusting the throttling valve of the cream outlet; if the valve is completely closed, all milk will be discharged through the skim milk outlet. As the valve is progressively opened, larger amounts of cream with diminishing fat contents are discharged from the cream outlet.

With direct standardization the cream and skim are automatically remixed at the separator to provide the desired fat content. Some basic standardization problems including mass balance and Pearson square approach can be viewed.

2.4.3 Homogenization

Milk is an oil-in-water emulsion, with the fat globules dispersed in a continuous skim milk phase. If raw milk were left to stand, however, the fat would rise and form a cream layer. Homogenization, is a mechanical treatment of the fat globules in milk brought about by passing milk under high pressure through a tiny orifice, which results in a decrease in the average diameter and an increase in number and surface area, of the fat globules. The net result, from a practical view, is a much reduced tendency for creaming of fat globules. Three factors contribute to this enhanced stability of homogenized milk: a decrease in the mean diameter of the fat globules (a factor in stokes law), a decrease in the size distribution of the fat globules (causing the speed of rise to be similar for the majority of globules such that they don't tend to cluster during creaming), and an increase in density of the globules (bringing them closer to the continuous phase) owing to the adsorption of a protein membrane. In addition, heat pasteurization breaks down the Cryo-globulin complex, which tends to cluster fat globules causing them to rise.



Raw Milk | Cold, raw Milk after 1 hour | Homogenized milk during storage.

Fig 2.2: Milk in different stages

Homogenization Mechanism

Auguste Gaulin's patent in 1899 consisted of a 3 piston pump in which product was forced through one or more hair like tubès under pressure. It was discovered that the size of fat globules produced were 500 to 600 times smaller than tubes. There have been over 100 patents since, all designed to produce smaller average particle size with expenditure of a little energy as possible.

The homogenizer consists of a 3 cylinder positive piston pump (operates similar to car engine) and homogenizing valves the pump is turned by electric motor through connecting rods and crankshaft.

To understand the mechanism, consider a conventional homogenizing valve processing an emulsion such as milk at a flow rate of 20,000l/hr, at 14 Mpa (2100psig). As it first enters the valve, liquid velocity is about 4 to 6mls. It then moves into the gap between the valve and the valve seat and its velocity is increased to 120 meter/sec in about 0.2 millisec. The liquid then moves across the face of the valve seat (the land) and exits in about 50 microsec. The homogenization phenomena is completed before the fluid leaves the area between the valve and the seat, and therefore emulsificaiton is initiated and completed in less than 50 microsec. The whole process occurs between 2 pieces of steel valve assembly. The product may then pass through a second stage valve similar to the first stage. While most of the fat globule reduction takes place in the first stage, there is a tendency for dumping or clustering of the reduced fat globules. The second stage valve permits the separation of those clusters into individual fat globules.

Unhomogenized | 1-stage (2500 psig) | 2 - stage (2500/500psig)

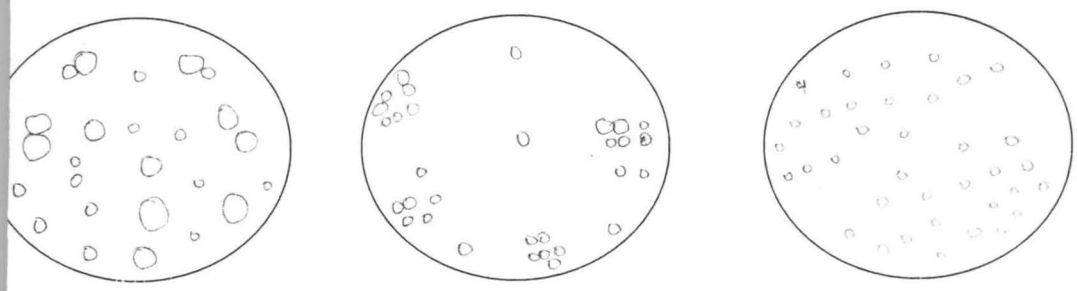


Fig 2.3: The Effects of 2 – stage Homogenization on fat Globule size

Distribution as seen under the Light Microscope

Mean 2 Um	Mean 0.5 Um	Mean 0.5 Um
Rabge 1-10 Um	range 0.2 - 2 um	range 0.2 – 2 Um
	Much clustering	no clustering

It is most likely that the combination of two theories, turbulence and cavitations, explains the reduction in size of the first globules during the homogenization process.

Turbulence

Energy, dissipating in the liquid going through the homogenizing valve, generates intense turbulent eddies of the same size as the average globule diameter. Globules are thus turn apart by these Eddie currents reducing their average size.

Cavitations

Considerable pressure drop with change of velocity of fluid. Liquid cavitates because its vapour pressure is attained.

Cavitation generates further eddies that would produce disruption of the fat globules.

The high velocity gives liquid a high kinetic energy which is disrupted in a very short period of time. Increased pressure increases velocity. Dissipation of this energy leads to a high energy density (energy per volume and time). Resulting diameters is a function of energy density.

- Type of valve
- Pressure
- Single or two-stage
- Fat content
- Surfactant type and content
- Viscosity
- Temperature

Also to be considered are the droplet diameter (the smaller, the more difficult to disrupt), and the log diameter, which decreases linearly with, log p and levels off at high pressures.

iii) **Effect of Homogenization:**

Fat globule (60p).

	No Homogenization	10 Mpa (2500psig)
Av. diam. (μm)	3.3	0.4
Max.diam. (μm)	10	2
Surf. Area (M^2/ml of milk)	0.08	0.75
Number of globules (μm^{-3})	0.02	12

iv) **Surface layer**

The milk fat globule has a native membrane, picked up at the time of secretion, made of amphiphilic molecules with both hydrophlic and hydrophobic sections. The membrane lowers

the interfacial tension resulting in a more stable emulsion. During homogenization, there is a tremendous increase in surface area and the native milk fat globule membrance (MFGM) is lost.

However, there are many amphiplutic molecules present from the milk plasma that readily adsorb: Casein micelles (partly spread) and whey proteins. The interfacial tension of raw milk is 1-2mN/m immediately after homogenization it is unstable at 15mN/m, and shortly becomes stable (3-4mN/m) as a result of the adsorption of protein. The transport of proteins is not by diffusion but mainly by convection. Rapid coverage is achieved in less than 10 sec but is subject to some rearrangement.

Surface excess is a measure of how much protein is adsorb; for example $10mg/m^2$ translates to a thickness of adsorbed layer of approximately 15nm.

2.4.4.Pasteurization

Definition:

The heating of every particles of milk or milk product to a specific temperature for a specified period of time without allowing recontamination of that milk or milk product during the heat treatment process.

Purpose: There are two distinct purposes for the process of milk pasteurization.

(1) Public health Aspect – to make milk and milk products safe for human consumption by destroying all bacteria that may be harmful to health (pathogens)

(2) Keeping Quality Aspect – to improve the keeping quality of milk and milk products. Pasteurization can destroy some undesirable enzymes and many spoilage bacteria. Shelf life can be 7,10,14 or up to 16 days.

The extent of microorganism inactivation depends on the combination of temperature and holding time. Minimum temperature and time requirements for milk pasteurization are based on

thermal death time studies for the most heat resistant pathogen found in milk, coxelliareburnettii. Thermal lethality determinations require the applications of microbiology to appropriate processing determinations.

To ensure destruction of all pathogenic microorganisms, time and temperature combinations of the pasteurization process are highly regulated.

Methods of Pasteurization

There are two basic methods, batch or continuous.

a) Batch method

The batch method uses a vat pasteurizer which consists of a jacketed vat surrounded by either circulating water, steam or heating coil of water or steam.

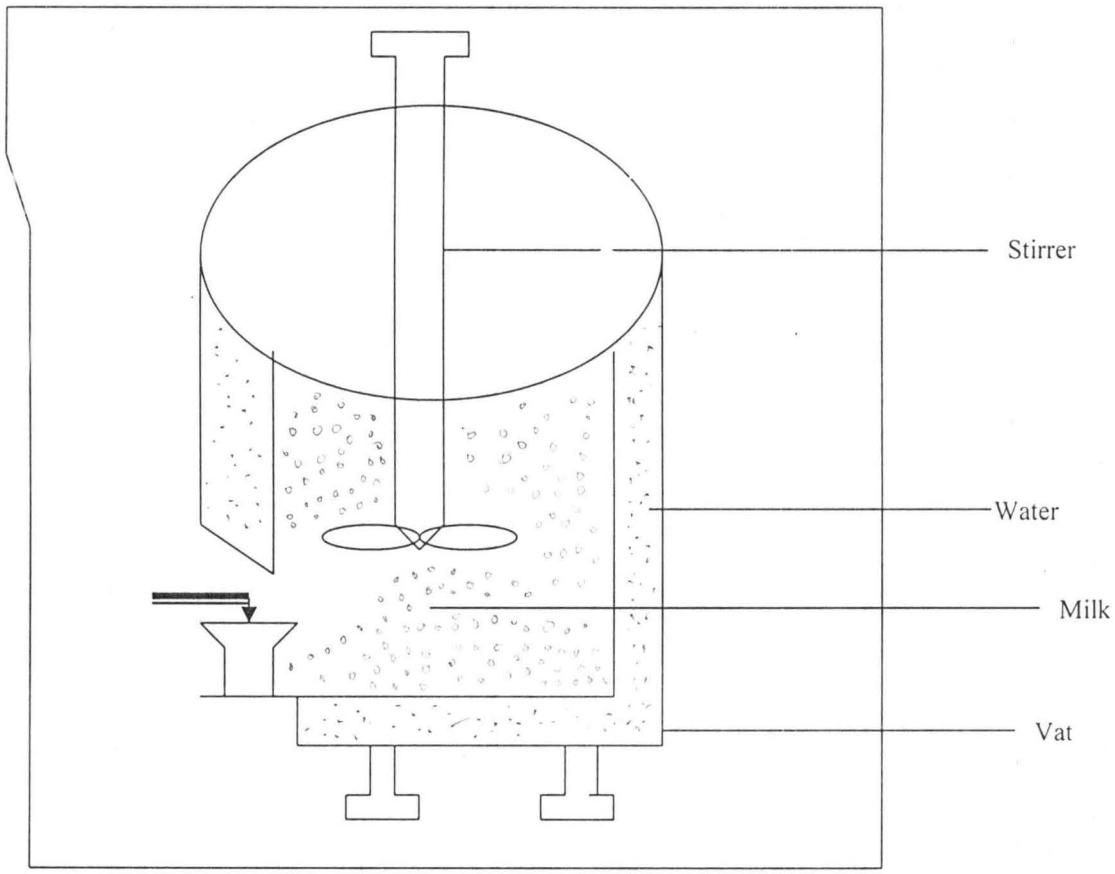


Fig 2.4: Batch Pasteurizer

In the vat the milk is heated and held throughout the holding period while being agitated. The milk may be cooled in the vat or removed hot after the holding time is completed for every particle. As a modification, the milk may be partially heated in tubular or plate heater before entering the vat. This method has a very little use for milk but some use for milk by-products. The vat is used extensively in the Ice cream industry for milk quality reasons other than microbial reasons.

b) **Continuous Method.**

Continuous process method has several advantages over the vat method, the most important being time and energy saving. For most continuous processing, a high temperature short time (HTST) pasteurizer is used. The heat treatment is accomplished using a plate heat exchanger. This piece of equipment consists of a stack of corrugated stainless steel plates clamped together in a frame. There are several flow patterns that can be used. Gaskets are used to define the boundaries of the channels and to prevent leakage. The heating medium can be vacuum steam or hot water.

Cold raw milk at 4°C in a constant level tank is drawn into the regenerator section of pasteurizers. Here it is warmed to approximately 57°C – 68°C by heat given up by hot pasteurized milk flowing in a counter current direction on the opposite side of thin, stainless steel plates. The raw milk, still under suction, passes through a positive displacement timing pump which delivers it under positive pressure through the rest of the HTST system.

i) **Holding Time**

When fluids move through a pipe, either of two distinct types of flow can be observed. The first is known as turbulent flow which occurs at high velocity and in which eddies are present moving in all directions and at all angles to the normal line of flow. The second type is

stream line or laminar flow which occurs at low velocities and shows no eddy currents. The Reynolds number, is used to predict whether laminar or turbulent flow will exist in a pipe.

Re<2100 laminars

Re>4000 fully developed turbulent flow.

There is an impact of these flow patterns on holding time calculations and assessment of proper holding tube lengths.

The holding time is determined by timing the interval for an added trace substance (salt) to pass through the holder. The time interval of the fastest particle of milk is desired. Thus the results found with water are converted to the milk flow time by formulation since a pump may not deliver the same amount of milk as it does water.

ii) **Pressure differential**

For continuous pasteurizing, it is important to maintain a higher pressure on the pasteurized side of the heat exchanger. By keeping the pasteurized milk at least 1 psi higher than raw milk in regenerator, it prevents contamination of pasteurized milk with raw milk in event that a pin-hole leak develops in thin stainless steel plates. This pressure differential is maintained using a timing pump in simple system, and differential pressure controllers and back pressure flow regulators at the dulled pasteurization outlet in more complex systems. The position of the timing pump is crucial so that there is suction on the raw regenerator side and pushes milk under pressure through pasteurized regenerator. There are other several other factors involved in maintaining the pressure differential.

- The balance tank overflow level must be less than the level of lavest milk passage in the regenerator

- Properly installed booster pump is all that is permitted between balance tank and raw regenerator.
- No pump after pasteurized milk outlet to vacuum breaker
- There must be greater than a 12 inch vertical rise to the vacuum breaker

The raw regenerator drains freely to balance tank at short –down.

iii) **Regenerator**

Heating and Cooling energy can be saved by using a regenerator which utilizes the heat content of the pasteurized milk to warm the incoming cold milk. Its efficiency may be calculated as follows:

$$\% \text{ Regeneration} = \frac{\text{Temperature increase due to regenerator}}{\text{Total temperature increase}} \quad \ldots\ldots\ldots\ldots\ldots\ldots 2.1$$

For example: cold milk entering system at 4°C, after regeneration at 65°C and final temperature of 72°C would have an 89.7% regeneration. (University of Guelph, 1999)

$$\frac{65-4}{72-4} = 89.7$$

2.4.5 Fermentation/incubation

The temperature and time of fermentations can be varied to influence final product characteristics. The fermentation temperature usually does not differ much from the optional growth temperature of starter organisms. It is essential that the temperature remains constant

during fermentation. Sometimes in order to improve the physical properties of the final product, manufacturers choose a lower temperature and longer time fermentation to promote formation of mucoidal capsules by some starter bacteria. For the stirred yogurt product, fermentation is carried out on the production tank or vat. (University of Guelph, 1999)

2.4.6.Cooling

A further cooling is allowed here to permit the packaging of the yogurt

2.4.7.Quality Control

At this stage, the product is assessed to confirm that the properties confirm to stipulated standards for food products. This involves ascertaining the bacterial count level, the pH, the palatability e.t.c. Except for the organized industries small scale manufacturers do not carry-out post production tests on the yogurt they produce. This therefore implies that taking locally yogurt has a significant level of risk bearing.

2.4.8.Packaging

Packaging of any product has some purposes. The main purpose is to contain the product. Other subsidiary reasons are:

(a) To preserve the product

(b) Advertise the product

(c) to protect the product from being damaged.

Packaging has some legal notes as the package carries information on the product, its quality level, content, constituents and the dates of manufacture and expiration. Yogurt is mostly packaged in any of the followings:

(1) Collapsible paper packs

(2) Plastic bottles

(3) Polyethene products.

The choice of a package depends upon the cost, the durability, ability to protect the product and local availability.

2.4.9.Storage

Yogurt is stored at temperatures in the range 5-8°C. This is why refrigeration is the best storage for yogurt, since it contains live and active acid forming bacteria (Delia and Herbert, 1986). Freezing is not desirable for yogurt during storage.

2.5.Machines/Equipment Facilities Required

There are various machines/facilities required for the various unit operations with yogurt production. These machines are employed during milk processing and after the yogurt been produced from the milk. The machine includes weighing balance which could be analog or electronic, centrifugal clarifier, standardizer, flow pipes tanks (mixing, cooling, storage, packing), processing pumps, homogenizer, pasteurizer, packaging machine, refrigerators or coolers, Agitators.

2.5.1.Clarifier

This removes the mechanical impurities present in milks and the somatic cells. This operation is carried out in centrifugal clarifier/separators but filtration of raw milk can also be used for this purpose. High centrifugation removes about 99 percent of the spores. There are however a specified centrifugal procedure for the removal of bacteria called Bactofugation (Frazierand Westhoff, 1978).

2.5.2.Standardizer

This is an equipment used to achieved the desired fat content in milk before pasteurization of milk is carried out.

2.5.3 Pasteurizer

This consist of mainly heat exchange sand a cooling chamber. The heat exchanger is an equipment for heat transfer and this can be divided into about four or five different types, the most commonly used heat exchanger in handling fluid or liquid are plate heat exchanger, tubular heat exchanger, other types of heat exchangers include scrapped surface heat exchanger, barred heat exchanger, cool heat exchangers, Drum heat exchangers.

(i) Plate heat exchanger comprises a group of trough or ridged plates, usually stainless-steel for food and drink applications, which are clamped and held in a frame. Each plate is separated and sealed by Synthetic rubber gaskets, which also separate the product and heating/cooling media. Failure of a gasket to seal is visually detectable as the spacing between each seal is vented to atmosphere. The principal characteristic of a plate heat exchanger is its ability to generate turbulent flow at low Reynold's numbers, giving rise to high heat-transfer coefficients. This means that, taking the standard formats for convective heat transfer.

$$Q = UA\Delta T \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 2.2$$

Q is the heat gained or lost, U is the overall heat transfer coefficient, A is the heat transfer area and ΔT is the logarithmic mean temperature difference, against a required transfer of heat reduction of either surface area (number of plates) or temperature difference can be made. The compact arrangement of a plate heat exchanger allows for large heat-transfer surface areas to be utilized in a relatively small space. And/or failure is the provision of heat recovery or regenerative heating /cooling sections within the plate pack.

2.5.4.Homogenizer

The high-pressure homogenizer may be regarded as made up from two parts, a high-pressure pump and one or more homogenizing valves. The high pressure-pump is usually positive displacement pump or lobe pump and atimes centrifugal pump are also used. The homogenizing valves could be either ball or poppets type.

(i) High pressure pump:- The liquid mixture to be homogenized is raised to the homogenization pressure a positive – displacement pump. In all but the smallest pumps there are at usually/three, sometimes five or seven, pistons. The pistons must be arranged so that they operate consecutively to maintain as even a feed pressure as possible. Both the pistons and the pump block are typically of stainless steel construction, but the piston seal rings are of composite material and can be a source of cleaning problems.

The mixture to be homogenized is feed into the pump block under a slight positive pressure. A gravity feed is sufficient to ensure that the inlet valves are flooded, but continuous operation may be better served by feeding a small positive pressure (e.g<0.1Mpa) from centrifugal pump via a preheater.

(ii) Two types of valves are used in the pump block either ball valves or poppet valves, the upper discharge valves are usually spring-loaded to ensures rapid closing. Valve leakage is the limiting factor the homogenization of liquids containing suspended by high-pressure homogenizers.

2.5.5.Cold storage Refrigerator

This is method for deteriorating living thing in the fresh form and its advantageous stage in storage sections for long duration controlling temperature and humidity conditions.

2.5.6.Agitator

This is use to stir the milk, it consist of a content shaft with spike and is driven by an electric motor. It is motorized. It mix milk with the starter culture before fermentation and after cooling when flavoured material or syrup has been introduced.

2.5.7.Tanks

Tanks are usually square rectangular or circular or cylindrical in shape it contains the milk either during storage, mixing cooling stage and they are all made of stainless steel. Every single equipment used in milk processing are usually made of stainless material to avoid contamination and migration of material to the food substance.

2.6.Dietary Importance and Importance of yogurt for different

Population Group

Yogurt is a fermented milk product and as such is a means of preserving the nutrients in milk. A wide variety of yogurts are now available around the world, ranging from very-low-fat fruit yogurts to Greek-Style Yogurt with a fat content around 8g per 100g. Yogurt can be made from cows, ewes, goats or bufflo's milk. This article reviews the nutritional composition of a range of yogurts provides data on yogurt consumption around the world.

Since yogurt is derived from milk, it provides protein, calcium and other minerals, and a range of Vitamins. Apart from its contribution to nutrient needs, the perception of yogurt as a "healthy" food has been augmented by claims of health benefits attributed to specific live bacteria present in some yogurt or flavoured yogurts in particular Lactobacillis acidophillus and bafidobacteria. Both of these types of bacteria are to be found in human gastrointestinal tract, especially in breast-fed infants, and it has been speculated that they may be able to colonize the gut when consumed via yogurt, and to protect against pathogens.

2.7. Considerations of Quality

The severe heat treatment received by the process milk, together with the low pH of the final product make yogurt extremely safe in respect to public health, for none of the recognized pathogens can survive or grow below pH 4.3. In addition, there is good evidence that metabolites from the yogurt organisms can actively depress the viability of many enteric pathogens, such as campylubacter, Escherichia or Salmmilk spp; so reinforcing the effect of acidity. Spoilage, however, can occur through the activities of acid-tolerant yeasts, or occasionally moulds, or through overacidification is starter activity is allowed to continue, e.g. prolonged storage above 5°C.

Yeasts in Food Storage

Widely distributed yeasts, like candida or saccharomyces spp; are frequently associated with gas formation and/or carton 'doming' of fruit yogurts for, in this situation, the natural fruit sugar's provide in abundance of substrates for fermentation. In natural yogurt, however, lactose is the principal sugar available and as few yeasts can ferment lactose, the major concern is kluyveromyces marximums var lactis or K. marximas Var. maximus.

In northern climates such problems should be infrequent but, even so, it is generally recommended that yogurt for the retail market should have a yeast count of <10 colony-forming units $(CFU)g^{-1}$. In warmer regions where active spoilage might be expected, the solution is either to reduce the "sell by" date of the product from 2-3 weeks (typical of the UK) to 4-5 days or, if the regulations permit, add sorbic acid (usually as potassium sorbet) at a level of up to 300 mg/kg. This preservative is extremely effective against yeasts, but has no action on the starter bacteria. This latter point is important, as yogurt, by definition, must contain an 'abundant population of viable bacteria of starter origin', and if any processing technique interferes with

this population, then the consumer has the right to be informed as the packaging. This general rules applies to all yogurts, and hence products that are pasteurized, for example, after the fermentation stage have to be labelled accordingly.

In general, over acidification is the result of poor storage, and the solution involves little more than improved monitoring of temperature. Nevertheless, it has been suggested recently that the problem of excess acid development during storage could be controlled, at least in stirred yogurts, by the addition of the antibiotic resin.

Other facts of quality, such as appearance, flavour or textural attributes like mouth feel', can be monitored by the use of taste panels and, in this context, the standards tend to be set by individual manufacturers/market demands. More objective assessments of, for example, the viscosity of stirred yogurt or the gel strength of set yogurt, are more readily attainable, and such values can be helpful to ensure that the quality of a particular brand remains relatively constant.

2.8. Methods of Preserving Yogurt-Based Product

The transformation of milk into yogurt, with a starter culture composed of streptococous solivrius ssp, thermophllus and lactobaallus delbrueckil ssp. Bulgaricus, c. easily extend the shelf life of milk from a few days to about 3 weeks. However, the application of the different preservation techniques known to humans for thousands of years could extend the shelf life of yogurt to a few months or even indefinitely. Examples of such past fementation processes include heating, concentration, freezing and/or drying, but it is evident that such treatments will alter the characteristics of the end product. Some of these processes are still carried out using traditional methods, but limited data are available in the literature; however, some of these processes have been mechanized and developed by industrial organizations and as a consequence, some technical data is somewhat limited.

2.8.1. Pasteurization

Traditionally, natural yogurt in rural areas in the Middle East is heated gently for a few hours over low fires using a special wood, and the product is known as 'laban midakhan' or 'smoked yogurt'. The application of heat inactivates the starter culture organisms and their enzymes, as well as other contaminants, e.g undesirable bacteria, yeasts' and moulds. Using such methods enables the nomads in that region to extend the shelf life of yoghurt for a few weeks, or until they reach a market to sell their product. Alternatively. The hot yoghurt is placed in a clean jar and covered with a layer of olive oil or fallow, so that the 'smoked yoghurt' is preserved over the winter months.

In mechanized plants, natural/plain, fruit, flavoured or drinking yoghurts are subjected to heat treatment after the fermentation stage to prolong the shelf life of the product. The time temperature relationship, which are used to achieve this objective, are dependent on

(1) Level of acidity, (2) method of heating and packaging and (3) storage conditions. Set yoghurt is heated between 60 and 85°C for up to 50 minutes, and in some instances the heating is carried out under a pressure of about 0.2 Mpa. The other types of yoghurt are pasteurized UHT, which is heated at 65 to >100°C for up to 50. In general, the heating and packaging methods can be divided into the categories of pasteurized/UHT yoghurts given below.

Post fermentation heating of yoghurt causes the separation of the aqueous phase from the suspended casein particles. This is mainly due to the phenomenon of aggregation/dehydration of the caseins caused by heating at the isoelectric point (pH 4.6). Certain hydro colloids (e.g. pectins, alginate, carboxymethyl cellulose or prophylene glycol) are negatively charged and, when added to yoghurt before the heat treatment stage, they interact with the positive charges of

the casein below its isoelectric point, and the separation of the two phases in the product is avoided.

2.8.2. Traditional Process

The cold natural/plain yoghurt is stirred and emptied into cloth bags of about 25kg. The bags are stacked on top of each other in a vertical press which is located in a refrigerated room. Pressure is applied in order to assist in whey drainage for duration of 12-18 hours. On the following day, the concentrated product is emptied into a mixing bowl to obtain a uniform texture prior to packaging. Alternatively, long, horizontal filter cloths can be used; the long sides are supported on poles and are gently oscillated up and down, while slight latering pressure is applied. This method of processing is known as the modified 'Berge' system, and was developed in France in the mid 60's for the production of fresh curd cheese.

The application of more pressure and a longer dewheying stage will yield a product that contains >30% total solids, and is known as yoghurt cheese. This highly concentrated product can be shaped into balls by hand, placed in a jar and preserved in oil. In Lebanon mainly goat's milk is used for the production of yoghurt cheese, which is known locally as "labneh anbaris". Herbs and spices are added to the curd after concentration, and before it is shaped into balls, the product is referred to as 'chanklish' (in the Lebanon).

2.8.3. Pineapples

The Pineapple (Ananas Comosus (L) merr.), botanically a member of the ornamental Bromeliacease family, originated in tropical South America but is now widely grown in all tropical and subtropical areas of the world. In Spanish-speaking countries as Pina abacaxi; Portuguese as ananas for Dutch- speaking countries and as nanas in Southern Asia. More than

$4.5x10^6$ t, both fresh and canned, are marketed world wide each year from at least nine major countries, with the major cultivar by far being the large juicy-fruited smooth – leafed cultivar smooth cayenne. Wild pineapple varieties still grown in the tropical savannah of South America but most have small, seedy , fibrous fruits.

2.8.3.1Composition and Nutritional value

The pineapple fruit is typically a supplementary food rather than a staple. The pineapple's very sweet and sour taste, its mild aromatic flavour and firm succulent flesh in a large and attractive form makes it some what unique among foods. While very palatable by itself, it is equally used as a flavouring component, both cold and hot, making many other less attractive but nutritionally sound foods more edible. The nutrient profile of the pineapple is, in general, similar to many other fruits, containing high levels of carbohydrate and low levels of fat and protein. Dietary fibre constitutes about 14% of the dry matter and, as with most fruits, can be incorporated into a cholestrol-lowering diet. It vitamin c content is about half that in citrus, and the level of retinol equivalent (3 per 100g) is low compared to those of Pawpaw (Papaya) (153) and mango (356). (International Dairy Federation, 1989)

CHAPTER THREE

PARTS MODIFICATION AND TESTING METHODOLOGY

3.1 The description of the yogurt production plant

The yogurt production plant consist of the following functional parts

(i) The top covers

The top covers is the lids to the milk tanks, water jacket and lagging column concentrically arranged. It is seal to the fluid.

(ii) The stirring Unit

The stirring unit consists of a stirring shaft and a motor. It mixes the starter culture with the pasteurized milk before incubation.

(iii) Milk Tanks

The milk tank contains the raw milk to be processed and the processed milk. The milk tank also holds the pasteurized and homogenized milk during the incubation

(iv) Pumping Unit

This system is responsible for transferring fluid from point to another desired level

3.2 Modifications

3.2.1 Agitator

The problems with agitator are:

(i)The electric motor rated 100W, 240V was making odd sound when switched on; and

(ii) Stirring shaft was not in alignment with the motor shaft producing part for coupling and this made it impossible for the motor to drive shaft very well and when it was working, the stirring shaft wombled and hinder the rotation of stirring shaft.

Modifications

The electric motor was removed and it was discovered that the clearance between the casing and the shaft is much, and it was latter packed using a frame, so the odd sound was able to reduce to the bearest minimum.

(ii) The stirring shaft was removed and set to align with the driving shaft of the electric motor before welding and at the bottom the top cover; a bushing was used to house the stirring shaft before welding it to the basement of the top cover.

3.2.2 Heating Element Or Steam Boiler

The 2000W, 220V steam boiler that was placed at the bottom of the milk tank was bad .

Replacement.

The 2000W, 220V steam boiler was replaced with a new steam boiler with 2030W, 220V and was tested okay.

3.2.3 Pumping Unit

Problem

(1) Pumping machine was pulsating when switched on.

(2) Pumping machine was discovered pushing out milk from suction side instead of pulling milk.

(3) The position of placement of the pump was wrong due to the type of pump being used (i.e. centrifugal pump).

Replacement

(i) The pumping machine was discovered to have a low rating capacitor to that specified on the name plate rating of the motor. Eight micro farad was initially coupled in the pump but 10 micro farad capacitor was specify on the name plate. It was later replaced with a 10 micro farad capacitor.

(ii) The electric motor of the pumping machine was dismantled and the line that was lead out from the field coil or starter was changed and the shaft then rotate the way it was supposed and the suction side then pull milk and the delivery side all push out milk with high pressure.

(iii) Since we are using centrifugal pump, the liquid to be pumped have to be at the same level or below the centifugal pump but the position of the pump then was below the liquid or milk to be pump, this made it impossible for the pump to pump the milk from an elevation above it. If we are to use piston pump, the pump can be below the fluid or milk to be pump, therefore in turn affect the arrangement of the pipe.

(iv) A foot valve was placed at the end of each pipe that have direct contact with the milk substance to ease the rate of suction.

3.2.4 Top Cover

Problem

No place of introducing the milk, before introducing the milk, the union connectors have to be remove.

Modification

A means of introducing the milk was provided using tee value placed on the top of the cover without removing the union connectors that connect the pipes.

3.3. Testing Methodology

The assembled machine was passed through both subjective and objective tests. Subjectively, the machine was tested by dry running it. This was to ensure that all the connections made were correct. The machine was plugged to the main and the source was put on, after water had been passed through to the water jacket. The temperature was set at 36°C.

The control system, the heating system, the pump and the motors were confirmed to be operational. The machine was further subjected to an objective test to ascertain the degree of functionally and performance of the units and the whole system. The objective test was carried out as reported below.

Materials

(1) 10 liters of raw milk

(2) 1 packet of Dano powdered milk

(3) Water (Varied Volume)

(4) Starter culture (Powdered) (Streptococcus Thermophillus and Lactobacillus Bulgaricus)

(5) 1kg of sugar

(6) 500g of stabilizer (Gelatin)

(7) Five goat weighing balance (10kg) capacity

Equipment

The fabricated yogurt production systems (existing)

Procedure

The test was carried out as follows:

(i) The machine was washed thoroughly to remove dirt and stains

(ii) A sample of the milk to be used was collected in sterilized plastic bottles for bacteria count and pH analysis

(iii) A measured volume of raw milk (8.5 liters) Vm, was poured into the milk tank through the provision made on the top cover by tee junction valve. The milk was mixed with 5 per cent sugar and/per cent stabilizer of the Vm

(iv) Five litres of water was passed through the pot to the jacket

(v) The thermometers was inserted to record the temperatures, Ta

(vi) The machine was plugged to the mains, the source switched on, and the heater button was pressed on

(vii) The motor switch was put on and turned to rotate the stirrer slowly. This was left until the control switched off. At this point, the temperature reading on the thermometer, Ta and the time it takes to reach that temperature, tx were recorded.

(viii) The system was left for 25 minutes; the heater switch was still on: After this time the heater was turned off and the motor turned to increase the speed of rotation for 2 minutes.

(ix) The water in the water jacket was drained out and cold water was passed through, to cool.

The milk. At the end, another sample "B" of the pasteurized milk was taken ina sterilized bottle for bacteria count and pH analysis.

(x) The conducting valves through the homogenizer were opened while the others were left closed and the pump switch was put on. Milk flowed through the homogenizer to the detention tank.

(xi) The conducting valves from the detention tank through the pump to the primary unit were opened while the others were locked and the pump was put on to transfer the homogenized milk back to the primary milk tank for incubation.

(xii) 10g of starter culture was mixed with warm water and introduced to the milk mixture through the use of funnel on the tee valve port to the milk tank. The heater was switched on and the motor was turned on to stir slowly for one minute only to evenly distribute the starter culture in the milk substrate. The mixture was left for four (4) hours (incubation period). The temperature was maintained (i.e. 44°C).

(xiii) After four (4) hours, the heater was put off, the valves conducting flow to the cooling tank were opened, while the others were closed and the pumped was powered on to transfer the yogurt to the cooling tank.

(xiv) Cold water was passed through the water jacket of the cooling tank for 35 minutes

(xvi) The samples A,B, and C, were analyzed in the laboratory for the followings:

(a) pH

(b) Odour

(c) Bacteria count

(d) Quality Evaluation

(xvii) I – xvi) above were repeated for one other sample of raw milk.

3.4 Specific Tests

Samples A,B,C, were tested specifically as follows, but each sample was tested for the variables at a time.

a) **pH Determination**

(i) A quantity of each sample was placed in a container

(ii) The pH meter was dipped into a buffer solution and left for 5 minutes to cleanse the nipples.

(iii) The terminal nipple was placed in a separate sample of the substrate to be tested and left for five minutes

(iv) The meter was then placed on the solution; and it was allowed to stabilized and the pH was measured.

(v) This was repeated for other samples and the subsequent tests.

b) **Colour Evaluation**

These test was carried out for the three samples each subjectively.

c) **Microbial Analysis of Yogurt**

Serial dilution:

Serial dilution is done so as to be able to count the number of micro-organism in a given yogurt sample. Ringer solution is used to antiance microbial multiplication in yogurt instead of ordinary distilled water.

(i) 9.0ml of ringer solution was dispursed in test tubes, corked and sterilized with autoclave at a temperature of 121°C for 15 minutes and then allowed to cool to 45°C before usage.

Ringer solution

1. Nacl = 0.85g
2. $Cacl_2$ = 0.029
3. Kcl_2 = 0.029

4. Na_2Co_3 = 0.02g

5. Distilled water = 100mL

NA - 28g/l

MCA - 56g/l

SDA - 62g/l

Plus

0.5g Chloramphenicol injection powder so as to inhibit the growth of bacteria.

(ii) Petridishes are sterilized in the hot air oven at 160°C for 1 hour and all were allow to cool before usage.

1.0ml of each, raw milk, pasteurized and yogurt was then transferred aseptically, a total of 6(six) tubes was used for each sample. The dilution 10^{-2}, 10^{-4}, 10^{-6} was then plate out.

Nutrient Agar (NA) was used for total viable count, MacConkey Agar (MCA) was used for total coliform count and soborecud dextrose Agar (SDA) was used for total fungal counts (yeast and moulds).

Similar tests was carried out for two other yogurt produced by different organised company in Minna. The samples of yogurt used are: yogurt from maizube farm and New life yogurt.

The same procedures, conditions and quantity were equally used and followed as for that carried out on the raw milk, pasteurized milk and yogurt produced from the Departmental yogurt production plant.

P = yogurt from Maizube

Q = yogurt from New life

d) **Quality Evaluation**

These tests were carried out for sample C only (yogurt) for taste and smell in the following manner:

(i) 80ml of three samples were prepared as follows:

Sample "Q"-yogurt produced by a local producer

Sample "P"- yogurt produced by the organized factory.

Sample "C"-yogurt produced by the fabricated machine

(ii) 60ml of each sample was placed in 5 clean glass containers

(iii) the three samples were served to five judges to taste and smell and score accordingly

(iv) This was repeated for one other production. Sample P was collected from a specific factory (Maizube Farm, Minna) while sample Q was also collected from local producer in Minna.

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.1 Results

4.1.1 Production Tests

Results of the production Tests is presented in Table 5.1.

Table 4.1: Result of Production Tests

Test No.	Type of Milk	Volume Treated (ℓ)	Heating Time (t) minutes	Thermometer Reading (^{o}C)	Incubation/ Fermentation Temp. (^{o}C)	Total Production Time (Hrs)
1	Raw milk	8.5	30.0	85.0	44.0	4.6
2	Raw milk	8.5	30.0	85.0	44.0	4.6

4.1.2 pH Determination

The purpose of determining the pH is to confirm whether the acidity of the yogurt correspond with the standard value. The result of the yogurt produced from the fabricated machine is as below.

Table 4.2 Result of pH Determination.

Production/ Test No.	Raw Milk (A) (Untreated)		Pasteurized milk (B)		Yogurt produced (C)	
	pH	Temp. (^{o}C)	pH	Temp. (^{o}C)	pH	Temp. (^{o}C)
1	6.0	25	6.7	32	3.1	22
2	5.78	25	6.11	32	3.50	22

Milk, in its natural state is expected to have pH of 6.6 to 6.7. (Artherton and Newlander, 1987). It could be seen that only one of the samples has close to this range. This could be explained as due to the time between collection and analysis which could result in the decrease in the pH i.e. it makes it more acidic. The temperature variation between the point of collection and point of analysis could affect the pH of the milk. Since the pH of milk is largely dependent on temperature (Shakuntala and Shadaksharawamy, 1986).

The pH of the produced yogurt is a little acidic in nature than the expected value. In addition, the processing time and the introduction of biological and chemical agents such as the starter and sugar and incorrect cooling of the yogurt could alter the pH level. In the production of yogurt, the temperature variation must be watched. This is because as a result of the phosphates, Gyrates and protein in milk, it become sour (i.e. acidic) when allowed to change temperature for a wide range of time.

4.1.3 Colour Test

Table 4.3 presents the subjective evaluation of the product.

Table4.3: Colour Evaluation

Product No.	Colour		
	Raw milk (A)	Pastemized milk (B)	Produced Yogurt (C)
1	Egg white	Dirty white	Dirty white
2	Egg white	Dirty white	Dirty white

4.1.4 Bacteria Count Test

The purpose of determining the bacteria count as to be able to count the number of micro-organism in a given yogurt sample.

Table 4.4: Bacterial count Results.

Nutrient Agar (NA)

Sample	10^{-2}	10^{-4}	10^{-6}	Av. CFU/ML
A	62	46	36	$2.09x10^{1}$
B	33	14	11	$1.1x10^{1}$
C	112	85	74	$3.8x10^{1}$

MacConkey Agar (MCA)

Sample	10^{-2}	10^{-4}	10^{-6}	Av. CFU/ML
A	83	56	41	$2.8x10^{1}$
B	54	38	26	$1.8x10^{1}$
C	169	112	89	$5.7x10^{1}$

Soborecud dextose Agar (SDA)

Sample	10^{-2}	10^{-4}	10^{-6}	Av. CFU/ML
A	16	10	6	$1.0x10^{1}$
B	9	5	3	Almost O Nil
C	34	26	14	$1.1x10^{1}$

Similarly for samples P and Q

Nutrient Agar (NA)

Sample	10^{-2}	10^{-4}	10^{-6}	Av. CFU/ML
P	38	18	15	1.27×10^{1}
Q	42	24	18	1.41×10^{1}

MacConkey Agar (MCA)

Sample	10^{-2}	10^{-4}	10^{-6}	Av. CFU/ML
P	60	44	32	2.01×10^{1}
Q	72	56	48	2.42×10^{1}

Sobercud dextrose Agar (SDA)

Sample	10^{-2}	10^{-4}	10^{-6}	Av. CFU/ML
P	12	8	6	0.4×10^{1}
Q	18	12	8	0.6×10^{1}

Key: AV = Total average count

CFU = Colony forming Unit = Unit of microbial grut

ml = Millilitre = 1.0ml of yogurt was used

Note: Av. CFU/ml for NA

$$= \frac{62\times10^{-2} + 46\times10^{-4} + 36\times10^{-6}}{3}$$

$= 0.209$

→ Total count x $\frac{1}{\text{dilution factor}}$.

→ $0.209 \times \frac{1}{10^{-2}}$

$= 0.209 \times 10^{2}$

→ $2.09 \times 10^{1} = 20.9$

Confirmatory and Complete test

This involves the gram's stain and fugal stain which is followed by series of biochemical test so as to name the organisms present in Nutrient Agar (NA) and MacConky Agar (MCA) are Bacillus spp and strept feacalis in Saborend dextrose Agar (SDA) it is yeast spp. and Tricophyton spp.

ii. **Methylene blue reduction test**

A = ++

B = +

C = +++

+ Is an indication of gravity of contamination. The more the number of + the less quality of yogurt i.e. B is more better than the rest.

Similarly for P and Q

(i) pH

P = 4.10

Q = 3.95

(ii) Methylene blue reduction test

P = +

Q = +

4.1.5 Quality Evaluation Result

Table 4.5 Quality Evaluation Result

	Judges (No)	1	2	3	4	5	Total	Mean
Scores	Q	3	2	3	2	0	10	2.0
	P	2	3	4	3	3	15	3.0
	C	3	3	3	2	2	13	2.6
	Total	8	8	10	7	5	38	

Analysis of variance

To perform the ANOVA, the scoring (using the Duncan multiple test) is totaled.

Scoring Summation

	Judges (No)	1	2	3	4	5	Total	Mean
Scores	Q	3	2	3	2	0	10	2.0
	P	2	3	4	3	3	15	3.0
	C	3	3	3	2	2	13	2.6
	Total	8	8	10	7	5	38	

Correction factor, CF = T^2/number of Judgements

$= 38^2/15$

$= 96.26$

Sum of Squares, Samples, SSs = $(10^2 + 15^2 + 13^2)/5 - CF$

$= 98.8 - 96.26$

$= 2.54$

Sum of Squares, Judges, SSj = $(8^2 + 10^2 + 7^2 + 5^2)/3 - CF$

$=302/3 - 96.26$

$= 100.66 - 96.26$

$= 4.4$

Sum of Squares, totals, SSt $= (3^2 + 3^2 + 3^2 + 2^2 + 2^2) - CF$

$= 108.66 - 96.26$

$= 12.40$

Table 4.5 ANOVA table

Sources of variation	df	ss	ms	F
Samples	2	2.54	1.27	
Judges	4	4.4	1.1	1.67
Errors	8	5.46	0.68	
Total	14	12.4		

Variance ratio, F = (sample) /Ms (error)

Therefore: F sample = 1.27/0.68

= 1.86

from ANOVA table, any value of F in excess of 3.44 has significant difference at 5% level and if it exceeds 5.72, it has significant difference at 1% level for degrees of freedom 22 against 2. The F value for Judges therefore, has no significant difference. To find which of the samples is significantly different, the standard error is determined.

$$SE = \sqrt{\text{MS Error/ No of Judges}}$$

$$= \sqrt{0.68/5}$$

= 0.36

The significant value for treatments against 22 degree of freedom is 3.56

	Q	P	C
Sample Scores are	10	15	13
The mean values are	2	3	2.6

Arranging the means according to magnitudes, we have

Q	P	C
2	3	2.6

Least Significant Difference (LSD) = 3.56x0.36

= 1.28

if the difference between any two samples is greater than the LSD, then they are significant different.

Comparing:

P to C = 3 – 2.6 = 0.4 < 1.28

P to Q =3 – 2 = 1 < 1.28

C to Q = 2.6 - 2 = 0.6 <1.28

P	C	Q
3.0p	2.6p	2.0q

4.1.6 Discussion of Results

From the results of the test carried out o yogurt that is, the pH test Colour Evaluation, Bacterial Count test and the Quality Evaluation test, it can be observed that the samples "Q and P" are the best, and finally followed by sample "C". But all the three samples are accepted for human consumption because the total average count is minimal, i.e. not heavy. It can only be heavy if it is between 30 – 300 colonies per ml. The present count can be taken care by the body immunity.

Sample "C" produced from the departmental yogurt plant is edible.

4.1.7 Fruit Yogurt Production

After the production of natural or plain yogurt, the fruit yogurt was produced by pasteurizing the fruit to be used for the production of the fruit (real) yogurt. The main objective is to produce pineapple yogurt but three other fruits were also used to produce

fruit yogurt i.e. (Pineapple, pawpaw, orange, apple). The proportion of fruit to be added to yogurt is usually 10 percent of the volume of yogurt for a particular sample considered.

The fruit used was cut into small pieces and pasteurized to a temperature of 95°C for three minutes after which the bottle i.e. plastic bottle to be used was sterilized and the pasteurized fruit was poured into the sterilized bottle i.e. 10 percent of the volume of the yogurt to be added, then cooled yogurt was now added and mixed thoroughly inside the containing bottle.

The following are the samples of the fruit yogurt produced.

Sample D - **Pineapple yogurt**

Sample E - **Pawpaw yogurt**

Sample F - **Apple yogurt**

Sample G - **Orange yogurt**

Table 4.6 Low-fat yogurt contains the following nutrients (with approximate percentage).

Nutrient	Fruit yogurt %	Flavoured yogurt %	Plain yogurt %
Water	75.0	80.0	86.0
Protein	4.8	5.0	5.0
Fat	1.0	0.9	1.0
Mineral	0.8	0.8	0.8
Lactose	3.3	4.8	4.6
Other sugar	14.6	9.2	1.6
Energy value per	(Mostly sucrose)	(Mostly sucrose)	(galactose)
100g	405kj	342kj	215kk

(Delia and Herbert, 1986)

4.2 Project Costing

The costing of the system can be broken down into:-

a. Material cost

b. Energy cost

c. Labour cost

d. Logistic costs

e. Operational cost

4.2.1 Material cost (spent) on the existing machine for the production of fruit yogurt

S/No	Material	Size	Qty	Unit Cost(N)	Total Cost
1	Heating Element	2 kW	1	1,800	1,800
2	Pump	0.5hp	1	1,600	1,600
3	Foot Valve	½ "	2	350	700
4	Starter Switch (gang)		1	600	600
5	Storing shaft	10mm	1	400	400
6	Tee coupler	½ "	5	40	200
7	Unim Connectors	½ "	5	70	350
8	90° Elbows	½ "	4	30	120
9	Sockets	½ "	6	30	180
10	Thread tape/yarn rope		Item	400	400
Total					6,350

4.2.2 Labour Cost

Labour charge per artisan per hour = ₦250.00

Number of artisans hired = 1

Number of hours worked = 4

Total Labour Cost ₦250x1x4 = ₦1,000.00

4.2.3 Operational Cost

The cost of running the machine can be estimated using the power consumption estimates

S/No.	Equipment	Rating (W)	Time of use (hrs)	Power consumption (Wh)
1	Heating Element	2030	3.00	6,090.00
2	Pump (0.5hp)	375	0.45	167.55
3	Motor	100	1.00	100.00
		Total		6,357.85

Add 50% for delayed running, fluctuation in equipment rating etc.

Therefore, total power consumption estimate= (1.5x6,357.85)/1000kWh

= 9.54kWh

Charge per kWh = ₦6.00 (NEPA, 2003)

Maximum running cost = 9.54 x ₦6.00/kWh

= ₦57.24

4.2.4 Logistic Cost

A total of ₦ 1,500.00 was spent during the course of replacement and rectification of the machine.

4.2.1 Production Cost

(i) Raw milk = ₦ 1,500

(ii) Starter Cultures = ₦ 1,200

(iii) Bacterial Analysis = ₦ 15,000

(iv) pH Test = ₦ 500

Total ₦18,500

Grand Total Cost = ₦ 6,350 + ₦ 1,000 + ₦ 57.24 + ₦ 1,500 + ₦ 18,500

= ₦ 27,407.24

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

The existing yogurt production plant was modified and used to produced edible yogurt and the palatability test was also carried out on yogurt produced. The capacity of plant was 25 litres of yogurt per batch. The plant could pasteurize raw milk at 85°C resulting in yogurt with pH value 3.50. The yogurt production line is an improvement over the existing traditional method of producing yogurt. The tests showed that the machine works successfully. The human contact with raw milk during processing is reduced. With further modifications it could be eliminated. It was ascertained that yogurt was produced, using the fabricated system and it was efficient.

The pH values for raw milk, pasteurized milk, are in agreement with literature provisions but the pH value for yogurt was little acidic in nature. This could be due to incorrect cooling of the yogurt, since absolute control of temperature changes could not be achieved. The produced yogurt is very edible.

The equipment was found to be able to reduce bacteria content to less than the 5 percent recommended limit. Due to high rate of heat loss however, perfect incubation will be achieved at the expense of energy consumption.

5.2 Recommendations

To further improved on this system, the followings are recommended:

i. All the parts having contact with milk should be replaced with stainless steel materials to avoid contamination and migrations.

ii. The frame should be raised up to allow easy drain of water from the bottom of the cylinder.

iii. Cast iron should be used as the enveloping cylinder.

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Plate 1 The different samples of yogurts

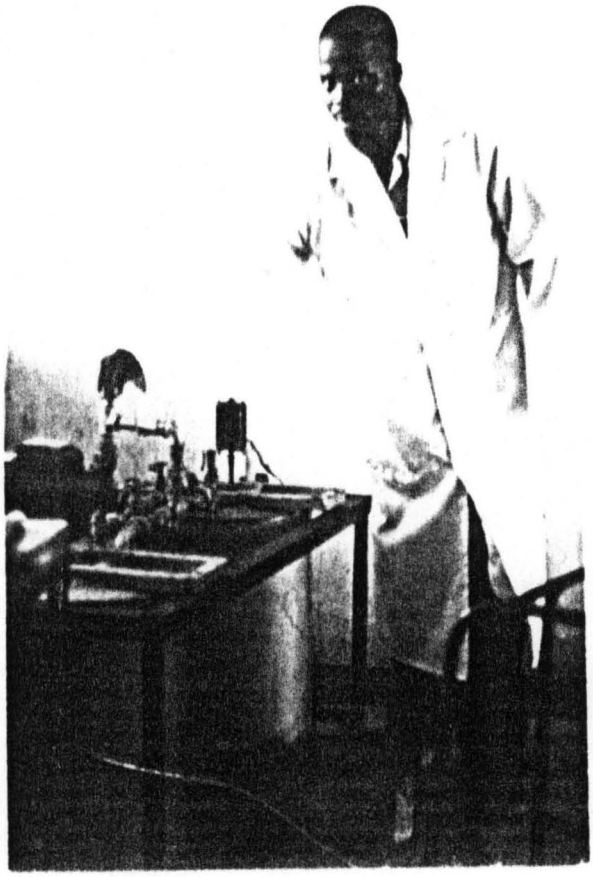

Plate 2 A stage during production of yogurt