Production and Operational Study of a Local Product in Nigeria. Case Study; Xx Yogurt Company in Ota

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Abstract- The Nutritional value of yogurt cannot be overemphasized owing to its general acceptance in the world at large. The product focus for this study is yogurt. It is a local product that is produced by a medium scale company in Ota, Ado-Odo local government area, Ogun State, Nigeria. Their production procedure conforms to the set standards for yogurt production as approved by Standard Organization of Nigeria (SON) and the National Agency for Food and Drug Administration and Control (NAFDAC) in the country such as milk standardization, homogenization, pasteurization, fermentation, cooling, homogenization or smoothing, filling and storage. This research work was carried out for 90 days to study the production process of the xx yogurt, marketing strategy and the likely challenging face by the company. The system runs a very lager line plant layout, and carried out regular preventive maintenance to keep the plant running year-round in a bid to avoid unnecessary additional cost of operation owing to system breakdown as an inevitable eventuality that results from ill-maintenance practices. Their major market is within the Ota metropolis which is actually a great limitation on product visibility and patronage by more end-users. This evaluation study shows that yogurt production process can be stable and more profitable if better marketing strategy and good infrastructures facility can be employed for the production process.
Keywords; Pasteurizing, Production of yogurt, Water Treatment, Quality Assurance

1. INTRODUCTION

Yogurt is a generic name for a universal product that is gotten through the fermentation of milk specific microorganism readily accepted by most localities in the countries of the world as it is called several names. In was earlier said to be believed that the word "yogurt" emanated from a Turkish word called "yogurmak" meaning "to thicken, curdle or coagulate" [1]. In the acceptance of yogurt by various categories of end-users, texture and flavor amongst other things are very germane factors of consideration. The flavor and texture parameter of yogurt for quality analysis is affected by processing conditions, temperature, incubation and starter culture [2] There is a general way to produce or manufacture yogurt but the pattern of application could be varying or contextual depending the quality desired and the scale of production [3]. Benelam, [4], stated that yogurt of high protein content has immense benefits as in terms of diets that are calorie restricted due to the fact that the amount of energy from carbohydrate or fat intake is lesser than that from protein. There are varying protein levels in yogurts as a result of the quality parameters of the materials used in the production [5-6].

A lot of things could go wrong while carrying out the processes involved in the production of yoghurt especially in a developing country like Nigeria. These problems come up right from the delivery of the raw inputs as they go through the various machines, down to the transport and delivery system of the final output [7-9]

Some of these challenges are listed below;

Poor infrastructures: Poor infrastructures (like poor road networks and unreliable transport systems) could cause late delivery of raw materials. When consignments do not arrive as at when due, it leads to a shortage in production and inability to meet the demands of the customers.

At delivery of raw materials to the factory, fake materials or materials that do not meet the required specifications could be delivered. When such products are used, the output is either toxic to health or changes the physical and/or sensory qualities of the final product (and everybody knows consistency is key for a successful business). This is one of the reasons why it is necessary to conduct series of physical, chemical and sensory tests on raw materials before they are used.

Inadequate storage facilities: When raw materials are delivered, they are usually kept in the store till they are needed. In the store, they are prone to spoilage. For example, Maillard reactions are induced in milk powder when the storage area is maintained at high temperatures. Other factors such as light intensity, exposure to oxygen and water activity or humidity of the storage environment have adverse effects on the shelf life of powdered milk. As a preventive measure, raw materials are used up on a first in, first out (FIFO) basis.

Failure of staff and workers to comply with the standard operating procedures and GMPs guiding the production of yoghurt: Milk is a very sensitive food commodity. The slightest exposure to any unsterilized environment contaminates it. Most contaminants found in the yoghurt (the final product) are introduced by the factory workers who fail to follow the basic safety principles guiding yoghurt production. This inevitably leads to a product of low quality and a shortened shelf life.

Inability to meet customers' demands: This is caused by late delivery, not having enough items in stock and uncompetitive pricing leading to loss of sales. When sales are lost, gross profit is also lost and this if not combated as early as possible ultimately leads to bankruptcy.

Moreover, when a company is unable to meet the demands of its customer, the company runs the risk of losing both present and potential customers

Inaccessibility to some areas: it is said to be similar causative factor to some remote areas which could be as a reason of terrible road network or poor visibility on market survey

Unstable power supply: all product producing company thrives well on good and steady power supply for substantial productivity. But the power status of the country poses a very strong limitation to consistency in productivity especially for low or startup business that can barely afford individually sourced alternative for power supply

Unavailability of raw materials: the materials that are used in the production of yogurt are not always readily available which could be as a result of several factors like inflation in prices of materials, embargo on importation and so on.

Corruption is the major economic cancer of the nation that greatly affect those in the lower business category as they do not have enough economic power to sustain the advert effect of the rampant economic and policy insincerity of the majority of those at the hem of affairs in the nation.

2. METHODOLOGY

The scope of the study limits the discussion to the production processes of XX Yogurt which is a local product produced in Ota, Ogun State, Nigeria. The processes involved in the production of XX Yogurt are shown in Fig 1.

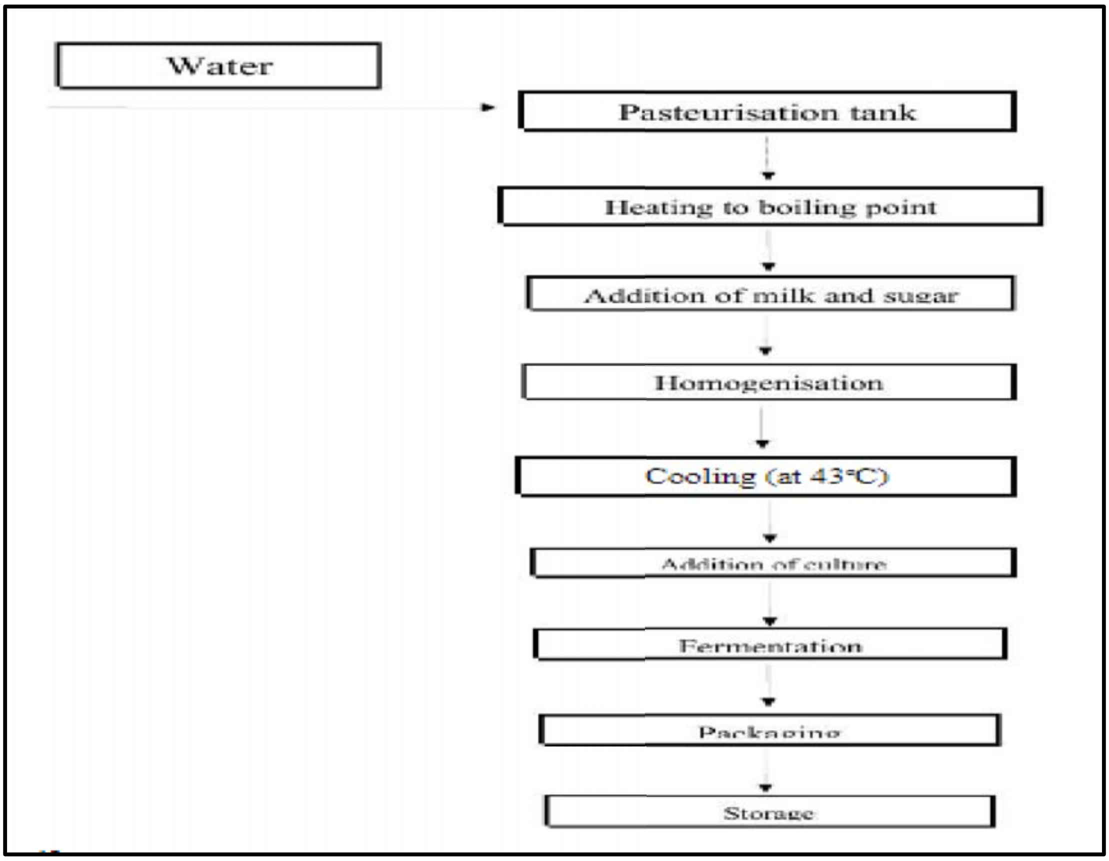

Figure 1: Flowchart for yoghurt production

2.1 PRODUCTION PROCESSES OF XX YOGURT

According to the benchmarks of the Standard Organization of Nigeria (SON) and the National Agency for Food and Drug Administration and Control (NAFDAC) product regulatory bodies for Nigeria the XX company produces her product (Yogurt) following the as received standards from the regulatory bodies with full alignment. The first step in the yogurt production is water treatment

The Water Treatment: Treating the water before it is used for the production process is very significant. At the water treatment plant, water from the borehole goes through the following stages; The raw water (or ground water) from the borehole is pumped and allowed to pass through the aeration tank as shown in Fig 2. Aeration is done to permit the entrance of oxygen and removal of excess gases. Aeration is also done to improve the taste and avoid odour by removing H_2S and other gases.

Figure 2: Aeration tank

Disinfection and storage, aerated water is now passed in the treatment tanks which are labelled A, B and C as shown in Figure 3. The water in the treatment tank is treated with 120g of soda ash and 5g of chlorine in order to disinfect it, thereby killing all harmful bacteria and toxic pathogens. After treatment the water is left for some time for the reaction to be completed.

Figure 3: Treatment tanks

Filtration: The treated water from the treatment tanks is then filtered as it passes through the sand filter and carbon filter to remove particles from the water. The sand filter shown in Figure 4 contains sands and stones of graded sizes with fine sand at the top and large stones at the bottom. The carbon filter helps to remove colour, odour and taste.

Figure 4: Sand and carbon filters

Sterilization: Filtered water is further treated by passing it through the pressure pump to the ozoniser and then to the micron filters of different mesh sizes (5µ, 2µ, 1.5µ, 0.5µ). Also, ultra violet light is used to sterilize the water in order to kill the bacteria. After the sterilization process, the water is ready to be used in the factory for the production proper.

Backwashing: This process is carried out before the commencement of each day's production. The filters are flushed by passing torrents of water through the filters to remove carbon and sediments. Backwashing helps to flush out sand, stones and other impurities that would have settled to the base of the filters.

Mix Standardization: This involves weighing the recipe to get the percentage of active ingredients in terms of proteins and carbohydrates.

Homogenization: This process involves mixing and dissolving the recipe to attain uniformity, increase the viscosity and avoid any flora. Homogenization is carried out within a temperature range of 65^{o}C to 70^{o}C.

Pasteurization: This is the application of heat which increases the temperature of the mix to about 95^{o}C to eliminate all inhibitors such as bacteria and pathogens. Pasteurization helps to increase the yoghurt's water holding capacity. It also increases the level of polypeptides and amino acids during fermentation.

Inoculation: This is the introduction of starter cultures of *Streptococcus thermophilus* and *Lactobacillus bugaricus* at a temperature of 40^{o}C-45^{o}C. The bacteria convert the lactose in milk to lactic acid-bacteria. This increase in acidity inhibits the growth of food poisoning bacteria.

2.2 QUALITY ASSURANCE

The term quality refers to those features and characteristics of a product that differentiates it from another and which contributes to the degree of acceptability or rejection of such product by the

potential consumer [10]. The quality assurance unit sets the policies, standards, methods and specifications for monitoring the quality of production. It is a means through which the food manufacturing plant keeps track of the properties of its inputs and outputs. It is necessary to enable a company to meet its legal obligations both regulatory and contractual. During food processing, foods are handled not only mechanically, but also manually and during this period, infections and contaminations may occur unless special precautions are taken. These precautions form the basis of quality assurance.
Some of these regular processes are; monitoring the various unit operations and performing analysis both chemically and biologically. Samples of water taken from the borehole, treated water tanks as well as factory water are subjected to physical examination and chemical analysis.

Physical Examination: The examination is carried out using three of the sense organs in the human body. They are eyes, nose and tongue. The parameters that are considered include appearance, presence or absence of sediments, taste, odour and colour. The examination is done on the raw materials as well as the finished products.

Chemical Analysis: This analysis is a routine analysis which involves determination of the conductivity, total dissolved solids (TDS), temperature, specific gravity, pH and titratable acidity. These analyses are carried out on the raw materials, semi-finished product (yoghurt mix) and the finished product(yoghurt)

Conductivity, TDS and Temperature: Conductivity measures the water's ability to conduct electricity. Because dissolved salts and other inorganic chemicals conduct electrical current, conductivity increases as salinity increases. Water conductivity is determined using a conductivity tester. This equipment can also be used to determine the temperature and total dissolved solids. Total dissolved solid is a measure of the dissolved combined content of all organic substances contained in a liquid (water in this case) in molecular, ionized or micro-granular suspended form. Usually, the TDS is half of the conductivity of the water being tested. This is a standard procedure that has been adopted for water treatment by several researchers [11-13]

Specific Gravity (SG): This test is done to ensure that the yoghurt is up to the required density specification. It is carried out using a specific gravity bottle and a weighing scale. The standard SG value for yoghurt is 1.030kg/m^3
The apparatuses used for specific gravity determination include a 50ml specific gravity bottle and a weighing scale.
Procedure

1. A clean and dried 50ml specific gravity bottle is weighed and the weight is recorded as 'a'
2. The bottle is then filled with water, cleaned and also weighed. The value obtained is recorded as 'b'
3. The bottle is emptied, dried, cooled and filled with the sample which is also weighed. The value obtained is also recorded as 'c'.

Specific gravity is then calculated as

$$SG=\frac{c-a}{b-a} \qquad (1)$$

pH Measurement: pH is a measure of the hydrogen ion (H^+) concentration which strongly influences the extent of changes that occur during food storage. The pH is measured electrically using a pH meter as shown in figure 5. The standard range of pH value for yoghurt is 3.5-4.5. Before pH measurements are taken, the pH metre is calibrated or standardized using buffer solutions 7.0 and 4.0.

Procedure

1. The prepared sample solution is poured into a beaker.
2. The pH electrode is rinsed with distilled water, wiped with soft tissue and dipped into the sample.
3. The pH value of the sample is then displayed on the screen
4. The process is repeated for the other samples.

Figure 5: pH meter

Titratable Acidity: This is determined by titration. The lactic acid present in yoghurt is titrated against NaOH using phenolphthalein indicator. The titer value obtained is then multiplied by 0.0098(standard value for lactic acid). The result obtained is the titratable acidity and it is expressed in terms of the particular acid (lactic acid in this case)

Procedure

1. 10g of the sample is weighed into a conical flask
2. The sample is diluted with 50ml of distilled water
3. 0.4ml of phenolphthalein indicator is added to the sample.
4. The sample is then titrated against 0.1M NaOH to a pink end point. The titre value is then recorded
5. The process is repeated 2 times

$$\%\text{Titratable acidity}=\frac{titre\ value*M*0.0098}{weight\ of\ sample} \quad \ldots\ldots (2)$$

Microbial Analysis: The tests performed for microbial analysis are generally categorized into three groups and they are all conducted in order to determine the Total Viable Count (TVC), coliform count and to check for the presence of *Escherichia coli*. The tests are;

Sanitary test: This is done to know the effectiveness of cleaning-in-place exercises.

Raw material analysis: On the arrival of consignment, samples of ingredients are taken randomly and aseptically by means of sterilized sampling devices into sterile containers. The sample containers are usually labelled to enhance traceability after analysis.

Semi-finished and finished product analysis: After the yoghurt has been homogenized, samples of the mix are collected aseptically using a scoop into sterile cups. Also, after packaging, coded yoghurt bottles are randomly picked. These samples are then analyzed.

2.3 Media preparation
Before the analyses, the media to be used must have been prepared. Also, the work surface, all equipment to be used as well as the prepared media must be sterilized.
The media used for microbial analysis include;

- **Potato Dextrose Agar** is the medium used to determine the yeast and mold count. It is prepared by dissolving 7.8g of PDA in 200ml of distilled water.
- **Nutrient Agar** is the media used to determine the total viable count. It is prepared by dissolving 4g of NA in 200ml of distilled water.
- **MacConkey Broth** is a differential medium for detection and enumeration of coliform in water and other varieties of food. It is prepared by dissolving 8g of MacConkey Broth in 200ml of distilled water. After preparation of the media, they are place in a water bath and heated to a temperature of 100^{o}C in order to dissolve them.

Inoculation and Incubation: The dissolved media are now sterilized in an autoclave. The samples to be tested are then inoculated and left to incubate. Yellow coloration in the MacConkey Broth samples indicate the presence of coliform. Microbial growths on the PDA and NA samples indicate the presence of yeast and mold.

2.4 HYGEINE AND SAFETY STANDARD IN THE COMPANY
The hygiene and safety standard at XX Company is upheld by implementing the principles of Good Manufacturing Practices and ensuring that the Standard Operating Procedures are duly followed.

Good Manufacturing Practices (GMP) forms an important part of the overall HACCP (Hazard Analysis and Critical Control Points) food safety system in a food industry. Good manufacturing practices can be defined as the operational requirements necessary to enable a food industry produce food safely. It is designed to minimize the risks involved in food production that cannot be eliminated through testing the final product.
Some of these good manufacturing practices are;

1. The walls are constructed with odourless, water-proof and easy to clean anti-corrosion materials
2. Personal hygiene is practiced by the staff

3. The machines and equipment are constructed and arranged in a way that avoids cross contamination.
4. Workers who are suffering from infections and injuries or not allowed to handle food.
5. The qualified raw materials are used on a “first-in-first-out” basis.
6. Tests and analysis records are kept updated.
7. Samples taken for analysis are labelled with their corresponding sources for easy traceability.
8. The packaging materials used are clean and non-toxic.
9. The factory is well ventilated so as to allow clean air thereby preventing contamination.
10. The refuse dump is constructed in a way that prevents offensive odour and toxic gases.

Standard Operating Procedure (SOP): is an established or prescribed method to be followed routinely for the performance of designate operations or in designate situations in a food industry. Some of these procedures are

1. Wash your hands before entering the factory
2. Ensure you are fully kitted at all times with a lab coat, boots, hair cover, nose mask and gloves (in that order).
3. Ensure your work surroundings are clean.
4. Change cleaning water as often as needed.
5. Remove lab coat, boots, hair cover and nose mask when you need to leave the factory.
6. Put on fresh gloves when coming back into the factory.
7. The factory is strictly out-of-bounds to non-factory workers
8. Avoid the use of cellphones in the factory.
9. Do not eat in the factory.
10. Avoid talking in the factory.

2.5 Plant layout

The adopted plant layout in the plant is product layout which could also be referred to as line layout. In this product/line layout type, only a single product is being produced for a given area of operation. For a justification of this a product layout, the product needs to be produced in high magnitude and must be standardized. The yogurt plant layout of the chosen case study is said to be product or line layout because all the machines and equipment are carefully arranged in the full operational sequence of the product. The advantages of the adopted layout are stated thus;

- Minimal work in progress
- Production control has greater simplicity
- Material in transit occupies less floor area for temporary storage.
- Minimized production time
- Lower cost of material handling

Conversely, the product layout is also said to have some limitations as listed thus;

- Increase in manufacturing cost owing to a fall in production volume.
- Machine idleness could occur if there is a very light running of one or two lines in the layout.

2.6 Maintenance Practice

The type of maintenance practice adopted by the company preventive maintenance which is further executed via periodic and predictive maintenance, this is in line with the study conducted by [14].

This maintenance pattern covers general servicing of functional part and replacement of consumables for the functioning of the machine or equipment in the factory for optimal performance. However, prompt responses are given when there is a need for urgent maintenance as there are modalities for eventualities that could affect the full operation of the plant. Preventive maintenance in this scenario is a comprehensive schedule of a daily maintenance schedule which involves oiling of and retightening of parts where needed, inspection and cleaning for the main purpose of retaining the full health status of the equipment alongside plant failure prevention via the deterioration preventive practice.
The extension of this practice as earlier mentioned is periodic and predictive maintenance.
Periodic maintenance for the plant involves the following;

- Periodic cleaning of equipment.
- Periodic inspection of the plant.
- Replacement of needful parts of the plant (equipment)
- Aims at the prevention of process failure and sudden failure of the plant

Predictive maintenance helps to further secure the plant via a robust data analyses on deterioration. It helps to utilize the various parts of the plant to the useful limit of service life through a prediction based on diagnosis or inspection of the plant.
The general objectives for observing the preventive maintenance practice are listed thus;

- Increase in efficiency and performance improvement of equipment.
- Improvement in meeting the production schedule daily.
- Reduction of maintenance and repair cost
- Reduce the cost of overall processing
- Conservation of raw materials
- Reduction/prevention of hazard
- Fuel conservation

3. CONCLUSION

Yoghurt is one of the most nutritious products obtained from milk, because apart from protein it is very rich in several vitamins and minerals such as vitamin B12, calcium, phosphorus and riboflavin. The company used for this study has got a robust modus operando for the production of XX yogurt with every other neighboring competitor in perspective. The factory setup is very laudable and environmentally friendly with full alignment to the standards of NAFDAC and SON. It is hence recommended that the company extends their market beyond the shores of the community of Ota for more visibility and patronage. Spares of very significant parts of the machine should be readily available in the store for easy replacement whenever the need arise.

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