



Mini-Review: Theoretical and Onsite Evaluation of Hazard Potentials in the Local Production of Wara; an Indigenous West African Soft Cheese

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Authors' contributions

This mini-review was carried out in collaboration among all authors. Author SIBC designed the review. Authors OMA and AJA managed the literature searches and wrote the drafts of the manuscript. Authors CAA and AAA made available the photographs from the field. All authors read and approved the final manuscript.

Mini-Review Article

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ABSTRACT

The effects of food hazards have been felt in various forms over the years by consumers globally. This study attempts to assess and evaluate pertinent hazards inherent in the local production of wara (West African soft cheese) which is traditionally produced in small scale by Fulani women and consumed widely in Nigeria. The producers of wara in most cases are associated with poor hygiene, and their products are usually inconsistent in quality and possess very short shelf life. The processes of milking (collection of milk) from animal sources, transferring of the milk into metal pots for heating, heating of the milk, addition of coagulum, ladling of curds and whey into basket and transferring to container of cool water were identified as possible hazard entry points, which a properly designed quality control system should address. To check these hazards, the Hazard Analysis and Critical Control Points (HACCP) system has been proposed, and a major inclusion of this system in local production processes is advocated.

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1. INTRODUCTION

In the food industry, hazards are described as any biological, chemical or physical properties inherent or acquired that may cause unacceptable health risk to the consumer [1,2,3]. By this definition, it is obvious that particulate and natural state of any contaminant in food is a means of identifying hazards in food. Hazards can be physical, chemical or biological depending on their nature. Examples of physical hazards in foods include rock particles, broken bottles, unwanted filth, and any other extraneous solid matter that is potentially injurious upon consumption. The chemical hazards include unwanted antibiotic residues, pesticide residues, and any other form of agents that alter product chemistry. Living organisms and their products form the biological hazards. These include microorganisms; and other parasites of minor and major sizes and types [4].

The growing global demand for protein requires that the animal protein source such as milk and milk products sold to the public should be safe and wholesome for human consumption. The occurrence of food poisoning worldwide has considerably increased public awareness about food safety and the need for better control of processing points to ensure safe and high quality product [5]. Analyses of foodborne disease outbreaks worldwide indicate that the greatest majority of foodborne disease outbreaks result from malpractices during food processing in small food businesses and other places where food is processed for consumption [6].

The nature of the food industry as obtained in the developing areas of the world has been heavily characterised by poor production methods and low quality assurance procedures [7]. In addition to this quagmire, a hunger scenario looms over these regions. This tends to drive desperate citizens into unwholesome, and low nutritive food production practices resulting in people eating only in a bid to temporarily ward off a persistent and debilitating form of hunger and various cheap and easily accessible foods have been produced locally. The Nigerian nation is not an exception in this case. With a population of over 150 million people, a lot of cheap snacks are available for consumption by a greater percentage of the populace. It is then pertinent that there should be appropriate mechanisms to check the quality of these foods.

There are varieties of snacks consumed locally in Nigeria and *wara* (West Africa Soft Cheese) is one of them. *Wara* is a soft white unripened cheese that originated from Fulani cattle rearers in the Northern part of the country [8]. *Wara* is traditionally made from cow milk. The manufacture of *wara* is widespread in Nigeria, and West Africa as a whole. It is commonly produced by Fulani women from unpasteurized cow milk and sold along major streets and local markets of Nigeria. Despite advances in science and technology in Africa, the production of this snack is still largely a traditional art associated with poor hygiene, inconsistent quality and short shelf life [8,9]. The traditional processing method for production does not take into cognizance quality control measures, while unhygienic conditions of milking and processing of cheese make the risk of microbial contamination very high. These contribute not only to the short shelf life of the product but also more importantly, to its potential health hazard [10]. The *wara* making processes in this paper come from the local Fulani processing unit operating in Southern Nigeria. The aim is to have an insight into hazards that may portend risks, so as to give credence into further investigation of the specificity and gravity of the dangers that abound in the production line

that will lead to the subsequent identification of critical control points to set an effective preventive system subsequently translating into safe production of *wara*.

2. WARA PRODUCTION

The preparation involves the usual separation of the curd from the whey that characterizes cheese production globally. The separation is based on coagulation, and the preferred coagulating agent is the juice extract of *Calotropis procera*, a local plant. However, the juice extract from papaya leaves (*Carica papaya*) and stems, and lemon juice are sometimes used [11,12]. *Wara* is unsalted and uncoloured; and based on the locally obtainable production process; about one kilogram of cheese will be obtained from about five liters of milk. *Wara* is usually sold on the day of manufacture and is brought to the market in a container of cool water. It is traditionally believed to have a relatively short shelf-life of 2-3 days. Fig. 1 shows the processes involved in *wara* production.

During the local production, the milking takes place on the open cattle fields (Picture 1). This environment is mostly infested by flies because of the cattle dung and other domestic waste inherent within the area. The process of milk collection is usually done early in the day. The young calves of the lactating cows are first allowed to suckle the teats thus stimulating unhindered milk flow (Picture 2). Without cleaning or antiseptically treating the udder or teat prior to the milking exercise, the milk collector subsequently uses bare (unwashed) hands in collecting the fresh morning milk. The milk from the cattle is usually collected into a largely unsterile and dirt laden milking vessel (not frequently washed) which may be a calabash or plastic container (Pictures 3 and 9). It is then transferred from the vessel to a metal pot which is placed over a slow burning fire of smoldering wood and heated to a temperature of about 50°C for 30 minutes. It is stirred gently (mostly) using unclean utensils during this initial and subsequent heating and cooking. At this point, the juice extract of *Calotropis procera* is added. According to Huber [13] and Hussein *et al.* [14], *Calotropis procera* known as giant milkweed, is a perennial, grayish-green, woody shrub with broad obviate fleshy leaves that grows wild in the tropics and in warm temperate regions. To prepare the extract, about 8 medium leaves are chopped on the floor in the open via a manual process of stone gnashing (Picture 4). With bare hands, it is then added to approximately 100ml of warm water and kept for about 5 minutes. The addition of the extract is done by first sieving the extract using a cloth filter usually unkept, and after that, it is added into 5-6 litres of already warmed milk. The milk is then heated gently with intermittent stirring until it reaches boiling point and it is kept at the boiling point until it coagulates and there is visible separation of curds and whey. Occasionally, floating impurities are removed by using local tin made sieves that may not be properly washed before use (Pictures 5 - 7). The pot is then removed from the fire and the curds and whey are ladled into the basket which facilitates whey drainage and also gives the cheese (*wara*) its characteristic shape and size (Picture 8). When the cheese is firm enough to retain its shape it is removed from the basket and placed in a container of cool water. It is available for consumption on the same day of preparation.

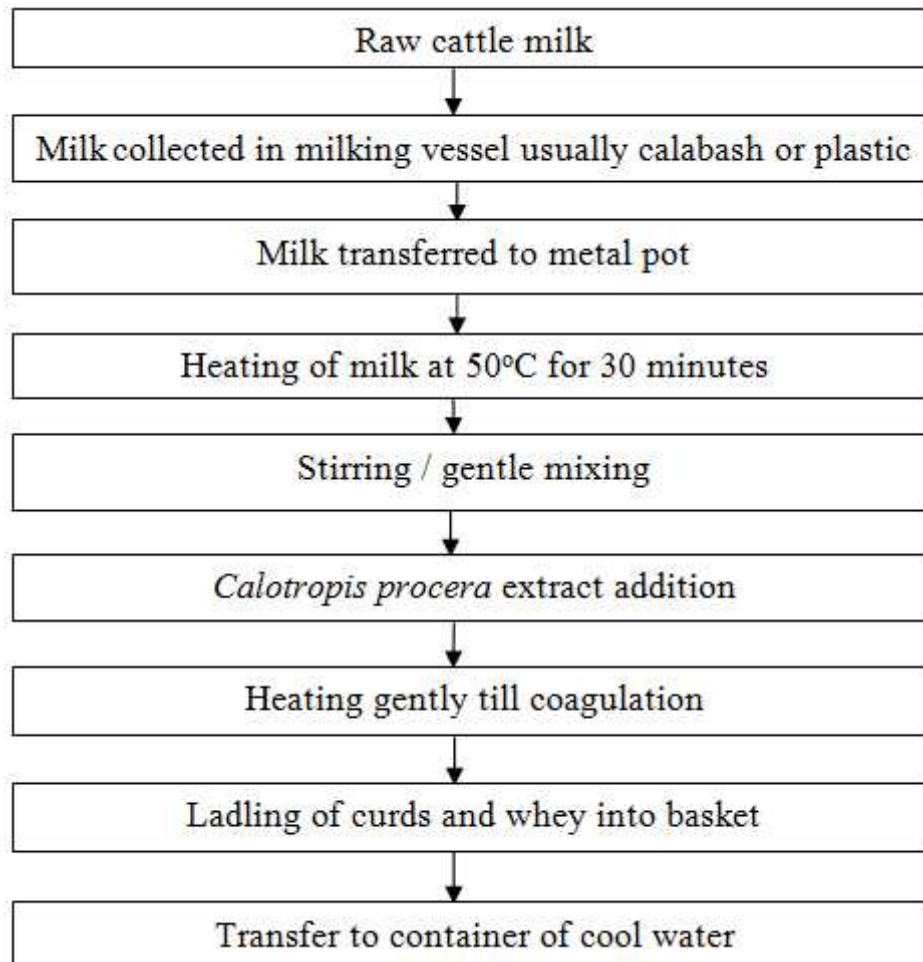


Fig. 1. Flow diagram of the traditional process of *Wara* production

3. MILK HYGIENE AND POTENTIAL HAZARD ENTRY POINTS IN *WARA* PRODUCTION

The concept of milk hygiene in food industry has a great deal of impact on the quality of the food. The factors that ensure good quality of raw milk are: the healthy state of the animal (cattle), the good quality of animal feeding, and proper stabling and milking conditions [15]. Biological, chemical and physical hazards, that directly affect the hygienic status of the milk, have been identified in raw milk and cheese produced in Nigeria. Nutritionally, milk is considered one of the most perfect foods in nature. It is in itself complete because it contains in it almost balanced proportions the necessary constituents of food for normal growth and development of the body. Cow milk is the most consumed non-human milk variant. According to O' Connor [11], cow milk carries important vitamins including vitamin A, thiamine, riboflavin, pyridoxine, niacin, pantothenic acid, and vitamin D. It also contains essential amino acids like casein, α -lactoalbumin, β -lactoalbumin, and immunoglobulins. Fresh cow milk contains 87.25% water with dissolved salt, 3.75% milk fat, 4.70% milk sugar (lactose), 3.40% proteins, 0.90% of other essential nutrients like potassium chloride, sodium

chloride, ash, calcium chloride, citrate, enzymes (lipase, galactose, amylase, lactose, reductase), dissolved gases (O₂, CO₂ and Nitrogen), somatic cells and immune bodies [3]. O'Connor [11] also evaluated the approximate composition of milk from different ruminant mammal species and stated that cow milk possesses 3.73% fat, 3% casein, 4.75% lactose, 0.4% albumin, 0.75% ash, and 87.3% water. The above facts imply that cow milk is a highly nutritious food element. This goes beyond human nutrition, as many other living agents can benefit from its nutritive quality. Microorganism of various metabolic properties can successfully thrive in a milieu of these nutrients. According to Frazier and Westhoff [3], the tangential evidence of microbial proliferation in milk is based on the presence of the ideal quantity of carbon, nitrogen and mineral sources as required by the organisms. The liquid state of the milk also enhances microbial growth, as compared to solid foods. A wide variety of microorganisms both pathogenic and non-pathogenic are known to thrive well in milk. The pathogenic ones are the major form of biological hazards inherent in milk and other liquid foods.

Biological hazards in milk products may include pathogens such as *Brucella spp* [16], *Staphylococcus aureus*, *Escherichia coli*, *Pseudomonas aeruginosa*, *Proteus mirabilis*, *Klebsiella pneumonia* subsp *rhinoscleromatis*, *Vibrio cholerae*, *Listeria monocytogenes*, *Serratia odofera* biovar *I*, *Clostridium botulinum*, *Streptococcus fecalis*, *Mycobacterium bovis* and *M. africanum* [7,12,17,18,20]. These can be derived from the udder (skin and mucous membrane of animal), the environment, the milk handling equipment/utensils, the personnel, and unhealthy cattle [19]; and are also sources of foodborne infection and intoxications. It is important to note that specific presence of some microorganisms in the milk product can serve as an indication for a source of contamination. An example is shown in the work of Adetunji et al. [20] which linked the presence of *E. coli* (which is usually killed at temperatures >55°C in 15 minutes) in *wara* as suggestive of post processing contamination. Chemical hazards may include plant toxins, antibiotics, and heavy metals. Antibiotics are a major chemical hazard, and either intramammary or intramuscular treatment of mastitis and periodic therapeutic dose of antibiotics contaminate milk and cheese with antibiotics such as tetracycline, oxytetracycline, bacitracin, chlortetracycline, penicillin, streptomycin and erythromycin [12]. In addition, heavy metal residues like lead, chromium, cadmium and zinc have been identified in cheese (Balogun, 2000 - *unpublished MSc dissertation, University of Ibadan, Nigeria* titled "Quantification of heavy metal contaminants and microbial activity of local soft cheese by atomic absorption spectrophotometry and antimicrobial assay methods"). These may enter the milk through intra-mammary therapy or through systemic administration of drug, lack of observance of the withdrawal periods, through transfer from feed and the environment. These substances may cause allergic reactions and may be carcinogens. Physical hazards include extraneous materials such as dust particles, metals, stones, and other unwanted objects, that can cause physiological damage to the gastrointestinal tract when consumed along with the milk.

4. STATUS OF RAW MILK FROM COW

As obtained on the field, the producers of *wara* do not always maintain good hygiene in their milking process. Often times, they use their bare hands which may not be properly washed and disinfected. They also obtain milk from unhealthy cattle. The environment used for milking is usually an open area where the animals roam freely and easily pass their excreta and other unwanted nitrogenous waste products. Another case is that the areas are also for domestic habitation and human wastes are also released into the environment. The Fulani herdsmen are nomadic in nature and are involved in movement from one place to another. This gives rise to their habitation in temporary structures including their toilet facilities and in

some cases; it leads to an occurrence of open defecation. The exposure of the milk to the environment laden with both animal and human wastes is a major hazard entry point. The unhygienic practice of milking the cattle with bare unwashed hands (picture 3) and without any form of antiseptic treatment of the udder prior to milking is of major concern. The containers for milk collection are not usually washed and they are also exposed in the open to flies and other filth associated insects (picture 9). The dusty surroundings also affect the quality of the milk obtained.

4.1 Transfer of the Milk into Metal Pots for Heating

The fresh milk is transferred into metals pot, and often the pots are washed with flowing water from the nearby stream or other source which may not be potable, containing pathogens.

4.2 Heating of the Milk

Heating the milk with gentle and intermittent stirring prevents the formation of skin and burn-on on the milk solids which could result in loss of valuable nutrients and discoloration of the finished cheese. However, the heating process is usually carried out using fire woods and the temperature is not regulated. It is also observed that the environment during the heating process is smoky largely due to the wood and the crude equipment used. The human traffic flow during the process raises dusts and sand particles thus introducing a lot of impurities that can affect the taste, nature and quality of the finished product.

4.3 Addition of the Coagulum

The coagulum often used is the juice extract of *Calotropis procera* believed to contain toxic substances which appears to be destroyed by high temperature (95°C) to which the milk is heated [11]. However, the addition of the juice extract can be a point of hazard entry. This is because, most times the leaves or stem are collected from the shrubs in the surrounding environments (earlier identified as unhealthy because of the improper sanitary practices) without being washed. They are then crushed on a grinding stone that is usually unwashed and exposed to contaminants (picture 4). The crushed leaves are then swirled in the milk using the unwashed bare hands of the processor in most cases (picture 5); this can result in the introduction of microorganisms such as coliforms from the hands of the processor, the grinding stone and the *C. procera* leaves and stems.

4.4 Ladling of Curds and Whey into Basket

In the normal practice of the producers, the basket used for whey drainage is a point where the cheese can be contaminated with micro-organisms because they can provide a favorable surface for microbial proliferation. The baskets are rarely washed as it is locally believed to confer on the product a unique flavor.

4.5 Transfer to Container of Cool Water

In the local production, the *wara* is transferred into water containers with unsafe water. This water serves as the carrier medium for the finished product as it is sold in the market.

5. APPLICATION OF HACCP

During milk collection, it should be stated that ideally, milk should be obtained from only healthy cows and under hygienic conditions. The animals that have mastitis should not be milked because the milk would be contaminated with *Staphylococcus aureus* and *Staphylococcus epidermidis*. Animals that are affected by tuberculosis are heavy reservoirs of *Mycobacterium bovis* and in some cases *M. tuberculosis* and *M. africanum* which is obtainable from their milk [18]. The udder of the cow should be cleaned with clean towel soaked in water containing antimicrobial agents to prevent exogenous contamination of milk before milking. The milk should be collected into clean stainless steel containers that have been washed with clean water and properly covered to prevent contamination by dust and flies from the environment, as microbial contamination of milk is an indication of poor sanitary practice [21]. The personnel milking should be in sound health not suffering from diseases such as typhoid fever or tuberculosis as this could result in the contamination of the milk by the causative agents. If medications especially antibiotic or acaricides are administered to the animal, such animal should not be milked until after the recommended withdrawal period; this is to prevent the presence of antibiotic residues in the milk as there are reports of drug residues in milk products [12].

During the transfer of milk into the pot for heating, Care should be taken as the metal pot could be contaminated by microorganisms found in the water obtained from the stream. The metal pot serves as source of contamination to the milk as some thermophilic microorganisms will survive the heating temperature of 50°C. There is therefore the need for proper washing of the metal pot with hot clean water and proper disinfection. The extraneous contaminants can be removed from the milk with metal sieve at this point. The sieve should be made of stainless steel that can be easily washed and disinfected.

In the addition of the coagulum, the unwashed leaves, bare hands and grinding stone can introduce hazardous microorganisms. To prevent this, the leaves and stems should be washed with clean potable water. The grinding stone should also be washed with hot water. Instead of the processor using his/her bare hands, the crushed leaves and stem can be placed in a clean piece of muslin cloth or similar cloth type and swirled in the milk for a few minutes. It is important that the muslin cloth is washed thoroughly and kept in a clean place. After the ladling of whey and curds into the basket, the baskets have to be thoroughly washed after each production with soap, mild disinfectant and clean water and allowed to dry well in the sun after which it should be kept covered and safe. As the *wara* is being transferred into cool water, it is important that the water should be of high quality. It should be potable with very low microbial contamination. The water container should be devoid of pathogens as this affects water quality. The water should also be cold so as to prevent the growth and multiplication of microorganisms by slowing down their metabolic rates [20]. These are standard procedures that should be adopted in the processing of local *wara*; however, that is not the case based on the obtainable reality.

In view of the above facts, several approaches have been proposed for checking the entry and effects of various hazards. In quantifiable terms, quality process reports conducted over the years have been linked to one major system of hazard control: The Hazard Analysis Critical Control Point (HACCP). HACCP system is a tool which guides food safety assurance personnel in identification of pertinent hazards and proffering measures to control the hazards at the points of entry. With increasing popularity and acceptance worldwide, particularly in large food producing factories, HACCP has been identified as a potent systematic approach to food safety designed to address biological, physical and chemical

based hazards in a preventive form rather than finished product inspection. It is well adopted in the organized food industry as a means of identifying potential food safety hazards, so that key actions can be taken to reduce or eliminate the risk of the hazards being realized [22]. After the HACCP was conceived in the 1960s by the US National Aeronautics and Space Administration (NASA), there was a massive international recognition of the HACCP system as a logical tool for adapting traditional methods to a modern, science-based, food safety system. It is important to note however that there have been various efforts in this regards. These efforts have been geared towards maintaining food safety and quality.

Public health and food control authorities worldwide have promoted the concept of Hazard Analysis and Critical Control Point (HACCP) which is described as an effective system based on Good Manufacturing Practice (GMP) and Standard Sanitation Operating Procedure (SSOP), for providing safe and healthy foods [22]. HACCP is being implemented with some degree of success in the large and medium-size food industries, however, much progress has not been made in small businesses where food safety problems are particularly important and better control of risk is needed [6].

HACCP has been identified as a possible quality control strategy to enhance the effectiveness and safety of the production process. The HACCP concept was originally for the food production/processing industry, and in many settings the concept of quality control has been wholly described only as a formal/industrial approach to food quality. This is however erroneous, according to Frazier and Westhoff [3], available surveillance data suggest that the incidence of food-borne disease outbreaks caused by mishandling of foods is actually higher in food service establishments and at the consumer level than in the industries. Therefore, the HACCP concept has been extended to food service establishments [23] and even to the home (Zotola and Wolf, 1980- *unpublished results cited in the sub-committee on Microbiological Criteria Committee on Food protection report*). Furthermore, the safety and qualities of foods domestically produced can be critical since those domestic foods also find their way into the open market for sale, thus commercializing the process making it equally as important. In the case of *wara*, several millions of Nigerians and West Africans alike consume this food everyday thereby making it a high value target for epidemiological and food safety concerns.

HACCP is borne on the following seven (7) principles [24]:

1. Conduction of a Hazard analysis by preparing a flow diagram of the steps in the production process, identification of the hazards and specification of likely preventive measures.
2. Identification of the Critical Control Points (CCPs) in the process.
3. Establishment of critical limits and target values which must be met in order to ensure the CCP is under control.
4. Establishment of a system to monitor control of the CCP by scheduled testing or observation.
5. Establishment of the corrective action to be taken, when monitoring indicates that a particular CCP is moving out of control.
6. Establish documentation concerning all procedures and records appropriate to these principles and their application.
7. Establish verification procedures which include appropriate supplementary tests together with a review which confirms that HACCP is working effectively.

To effectively do justice to this work, we shall attempt to simulate a situation of application of the above HACCP principles in the production process of *wara*. The following points have been deduced as a possible application mode for the seven principles.

- The production flow diagram is as described above. The basic interest of the hazard analysis is in the actual production line (Fig. 1) from which faults observed can be traced to prerequisite programmes (like pest control, allergen management, hygiene & housekeeping, waste management, cleaning & disinfection) usually in place before production starts. The hazard analysis based on hazard types and on each production step has been conducted in the previous parts of this paper.
- With a constructive view of the processing stages for the local *wara*, a fact can be easily identified that almost all the stages are important as control points due to the unhygienic nature of the total production. However, by virtue of quantifiable microbiological risk assessment, the basic critical control points identified in the processing of *wara* are shown in Fig. 2.
- Critical limits and target values that ensure the CCP is under control are based on operational standards in domestic cheese production as determined by individual research, national and international regulatory bodies. The presence (in colony forming units per milliliters) of pathogenic species like *Mycobacterium tuberculosis* Complex, Enterobacteriaceae, *Vibrio cholerae*, *Clostridium botulinum*, *C. perfringens*, *Listeria* species and others are to be kept at the barest minimum if possible at zero level. Testing to determine prevalence and incidence of microbial contaminants, chemical interference and presence of foreign bodies are essential. However, local enlightenment on the limits and standards set up by national and international regulatory bodies with respect to domestic cheese production is needed. With funds from individuals, government and donor agencies, massive orientation and sensitization on the institution and upgrade of quality management systems for *wara* production can be achieved.
- A monitoring and control system is valuable and can be instituted still with the aid of information gathered from the risk assessment of the whole process. The incidence, prevalence and subsequent deduction of the critical limits of important pathogenic microbial species can only be effectively determined via testing. This can be a major bottleneck given the fact that laboratory testing procedures are non-existent in the local areas where *wara* is produced, coupled with the zero literacy level of the producers involved. Continuous sensitization and general involvement of local health agencies in the distribution and teaching on understanding food hazards, developing an appreciation of personal hygiene, sanitation, and food hygiene, introducing risk factors affecting microbial growth and survival, and developing an understanding of microbial contaminants and control measures. However, rapid simple and inexpensive test kits can be introduced to aid the process of quality assurance. The application of these easy to use test kits can help to improve *wara* quality even among local producers.
- Corrective measures are also applied based on knowledge at the disposal of the producers. However, basic personal/culinary hygiene practices as well as environmental sanitation practices should be promoted. In the case of product distortion, local regulatory and health agencies are to teach on the actions to be carried out, together with the benefits of such actions to human lives.
- Local government based arms involved in agriculture, food production and safety should document and verify practices carried out above, as well as provide enforcement arms for product non-compliance. Product testing should be promoted

and adequate documentation should be made available. This is largely because of the unenlightened nature of most producers.

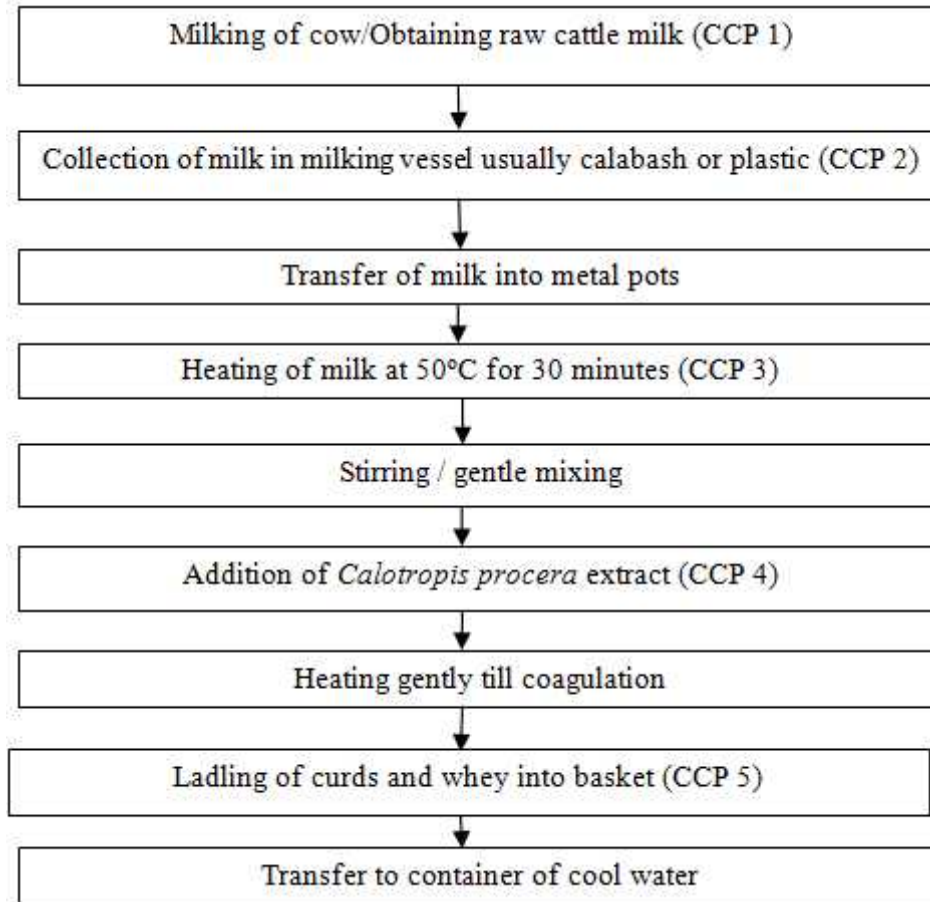


Fig. 2. Flow chart for wara production showing critical control points (CCPs)

HACCP process is an integral part of Good Manufacturing Practices (GMP) and GMP involves the whole production floor. The production floor in the case of *wara* is the whole society. With ease, one is tempted to look away, turning a blind eye since this food is only done domestically, but taking a critical look at the hazard potentials that abound, it is now clear that there is a need to upgrade Quality management systems to better the lives of *wara* consumers and West Africa at large.

6. CONCLUSION

The percentage of poverty stricken individuals in a low resource setting like Nigeria cannot be overlooked. It presses on the quest for sustainable feeding sources and nutritional elements to help these people meet their daily required amounts of essential nutrients and minerals. A good way of achieving this has been identified in this regard as the inclusion of cheap nutrient sources of which *wara* is an example. The process of production of this highly consumed food should thus be properly examined to identify areas of need in terms of

product quality, which will automatically rub off on the health of the final consumer. The ideas that have been elucidated in this paper make for feasibility studies on the potential hazards. They can be fully blown into a well documented and well reported HACCP plan specifically for *wara* production. This plan can thus be directed for use by the local people. It is highly essential that the government and other relevant bodies and agencies take a critical look at the production line, so as to upgrade it. This will be a conscious effort to alleviating the sufferings of the malnourished and poor masses that depend on foods like *wara*.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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APPENDIX



Picture 1. Cattle in the open field with dung and animal wastes around



Picture 2. Calf suckling the mammary gland to stimulate unhindered milk flow in the presence of a herd boy



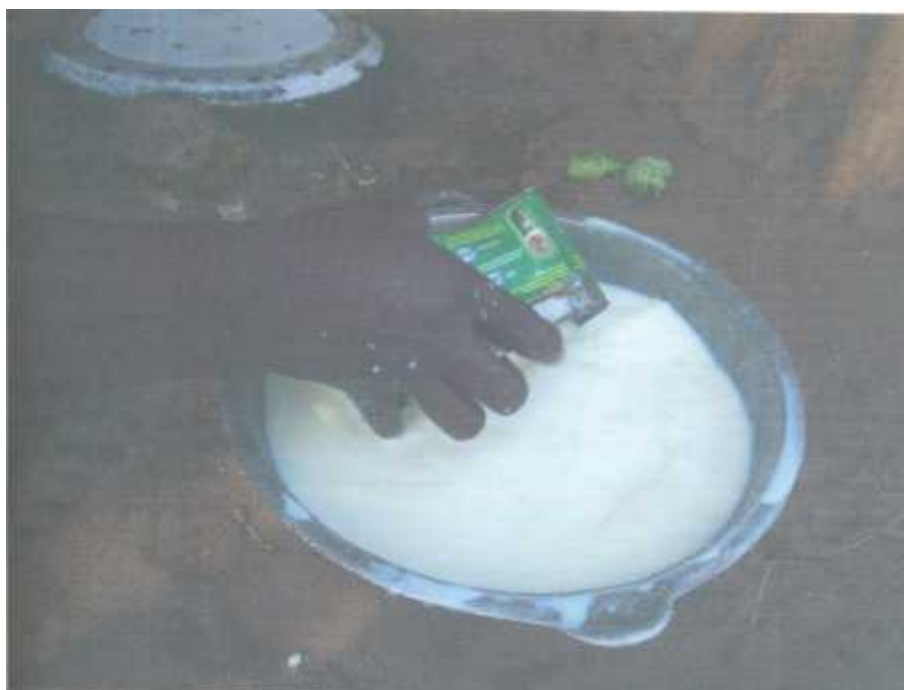
Picture 3. Milk being collected into an unclean calabash using bare unwashed hands



Picture 4. The pounding of *Calotropis procera* plant on a grinding stone on the floor



Picture 5. The mixing of the plant extract with the milk using bare hands



Picture 6. The sieving process using bare hands and unwashed metal sieve



Picture 7. The process of whey removal from the cuddled milk



Picture 8. The semi solid cheese in cane moulds



Picture 9. An exposed calabash/milk container with flies on the edges

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