

Production of an Improved Cultured Milk Product Similar to Indigenous East African Fermented Dairy Products.

Introduction: Characterisation of East African Cultured Milk

Background

In East Africa, milk has been traditionally processed into indigenous products both for domestic use and for sale. The commonly produced traditional fermented milk products throughout East Africa have different regional names, but organoleptically they are all similar.

Sserunjogi (1) reviewed the Ugandan indigenous fermented milk product, *makamo*, and reported that the production of *makamo* in Uganda has a high commercial potential, both domestically and for export. He has suggested that such products can be produced commercially in small scale industries in rural areas and thus reduce the need to transport highly perishable milk to distant processing plants. He suggested that production of this type of product may constitute a poverty alleviation strategy for rural milk producing communities.

It is envisaged that a similar product, processed under controlled conditions to obtain a high quality product, while having comparable organoleptic properties to the indigenous product, could be introduced into the general East African market, with a good chance of market acceptance and commercial success. An identical product is widely consumed throughout the eastern basin of the Mediterranean in the Middle East, where it is known as *lebaniyah* or *leben*.

The proposed product can be processed at both the village artisan level and also on a more industrial scale in a formal processing environment.

Traditional Production of Cultured Milk

Sserunjogi described the traditional process followed in the production of Ugandan *makamo* cultured milk, stating that it is traditionally made by fermenting raw milk. The fermentation is carried out in smoked gourds. The fermentation is initiated by using a portion of product from a previous production. The milk is allowed to incubate overnight (ca. 16 – 24 hours) and the fermentation is judged to be complete when the milk has formed a thick coagulum.

Smoked gourds are mentioned as being the preferred containers used at village level for preparing the product. To remove residues of previous product batches, the gourds are washed with water and the interior surface scrubbed using specific green herbs. The gourds are inverted and allowed to drain. The woven sisal container lids are similarly washed. Traditionally, the interiors of the gourds were also rinsed with warm cow urine. It is thought that the ammonium salts present in the urine possibly served as a cleansing agent.

After draining, but while still wet, the gourds are inverted over a smoking vessel made of clay. The barks of two specific trees are preferred for this purpose. The smoke produced is astringent when fresh, probably due to the presence of phenolic compounds. After smoking, the gourds are stored until use.

Makamo is commonly made from whole milk. Skim milk is not usually used for making the product, probably because the low fat content significantly changes the organoleptic qualities of the final product.

A small portion of *makamo* from a previous fermentation is used as a starter culture to initiate the fermentation.

The initiation of fermentation is sometimes aided by adding a small quantity of sugar to the raw milk and allowing the fermentation to proceed. Alternatively, a second method uses the inner skin from the bark of a specific local shrub and then allowing the fermentation to proceed naturally.

Makamo is a mesophilic fermented milk. It is sometimes packed in pouches for sale. Mesophilic products are advantageous in rural environments where facilities for temperature regulation, incubation and refrigeration, do not exist. The mesophilic microorganisms have optimum growth temperatures in the range of the ambient air temperature prevailing in Uganda.

Starter Cultures

The production of cultured milk products of consistent quality requires the use of starter cultures derived from a reliable source having guaranteed culture composition and quality characteristics.

The use of portions of a previous production as a starter culture, though a traditional technique, quickly leads to inconsistent product quality, contamination by undesirable species and ultimate product failure.

Consistent product quality can only be achieved by the routine use of commercial starter cultures that have been selected for their characteristics. Commercial cultures are reliable and impart the desired organoleptic characteristics to the product.

Artisanal, or wild, cultures are undefined mixtures of lactic acid bacteria, of complex composition, invariably contaminated with undesirable organisms whose presence negatively affects the characteristics of the final product. Wild cultures exhibit variable performance and are not compatible with effective processing aimed at producing products of consistent quality.

Subculturing of artisanal cultures inevitably leads to changes in the relative numbers of the various species present in the bacterial population of the component microorganisms. The changing population composition has a direct effect on product consistency and characteristics.

Commercial cultures are designed to overcome this problem and to provide a source of microorganisms that will deliver consistent, repeatable, desirable characteristics in the final product. The commercial cultures used in the dairy industry were originally derived from artisanal cultures, where organisms with desirable characteristics were isolated, propagated and incorporated into the commercial cultures offered for sale to the industry.

Microbial Flora Present in *Makamo*

Sserunjogi reported the following mean microbial counts in *makamo*.

Mean Microbial Count, \pm standard deviation (log cfu mL⁻¹)*

Bacterial Group	Mean count
Aerobic mesophilic count	7.1 \pm 1.5
Coliforms	2.0 \pm 1.1
Yeasts and Moulds	4.2 \pm 1.2
Non-Lactic Acid Bacteria	3.5 \pm 1.4
Lactic acid bacteria on M17**	7.4 \pm 1.0
Lactic acid bacteria on MRS***	7.4 \pm 0.8
Citrate metabolizers	6.4 \pm 0.8

*cfu = colony forming unit

**M17 = selective diagnostic growth media for differentiating *thermophilus spp.*

***MRS = selective diagnostic growth media for differentiating *Lactobacillus spp.*

Mesophilic lactic acid bacteria were the predominant flora present in the product.

The primary strains of lactic acid bacteria present in *makamo* were characterized and identified as *Lc. lactis* subsp. *lactis* and *Leuconostoc spp.* Both organisms produce diacetyl, which is the primary flavour compound of cultured milks, responsible for the characteristic flavour and aroma of these products.

The yeasts that were isolated commonly occur in milk and its products. Most of the strains exhibited a varying degree of lipolytic activity, which is believed to play a significant role in flavour development when *makamo* is used as the raw material for the production of a butter product *mashita*.

The presence of yeasts in *makamo* probably has no technological significance, but their presence should be regarded as undesirable contaminants.

Charateristic Flavour Compounds

Sserunjogi reported low levels of diacetyl, never above 1ppm in any sample tested, while ethanol levels were relatively high at 600ppm.

He suggests that though diacetyl was detected at low levels in the samples analysed, the fact that the taste threshold for diacetyl is low, this compound when present, probably contributes to the flavour of *makamo*.

Technological Characterisation of *Makamo*

Sserunjogi concludes that *makamo* as produced by different artisans or small scale processors, is a very variable product, with respect to some volatile compounds, organic acids, and also has a variable microflora.

The variability is attributed to the use of raw milk for the production, or starter culture of variable composition for making the product.

The conclusion drawn is that if products of the *makamo* type are to become part of the product range supplied by small or large-scale dairies in Uganda, the standardization of the culture is important. The introduction of a standardised culture will enable the product to be produced using pasteurised milk, thus improving its microbiological safety.

Proposed Methods of Production of an Improved Cultured Milk of Consistent and Acceptable Quality

General Considerations

Whether the product is manufactured at the artisanal or the processing plant level, to ensure day-to-day consistent product quality, successful production will require attention to a number of technological and processing parameters.

The primary requirement is that the product must be made from pasteurised milk. Pasteurisation destroys any pathogenic microorganisms that may be present, and therefore will ensure that the final product is safe for human consumption. Also, by reducing the bacteriological load of organisms in the milk, pasteurisation removes competitor microorganisms, so ensuring efficient growth of the starter organisms.

Handling of the milk throughout the processing operation must be conducted in a sanitary and hygienic manner. The shelf-life of this type of product is determined by the presence or absence of contaminating microorganisms. If sanitary and hygienic precautions and clean handling methods are maintained, the product will have a shelf-life of several days, even under marketing conditions where there is limited refrigeration. Product processed in a dairy plant and marketed through a cold chain will have an expected shelf-life of 10-12 days.

Local consumer preference apparently prefers a heavily viscous product. In a commercial processing plant viscosity can be enhanced in a number of ways. Village level processors do not have access to the necessary equipment, and an alternative procedure will be recommended.

In a formal processing plant the viscosity can be enhanced by:

Pasteurisation at a relatively high temperature, 85°C. The use of a high temperature increases the degree of protein denaturation in the milk, so improving its coagulation properties.

Extended holding time at pasteurisation temperature again increases the extent of denaturation of the whey proteins, so improving viscosity in the final product. The holding time should be 3 to 5 minutes. This is easily attained if a vat pasteuriser is used, but impossible if a plate pasteuriser is used for the process, unless it is fitted with an extended holding section in the plate pack or an extended holding tube.

The raw milk may be fortified by the addition of skim milk powder. Recommended powder fortification should be approximately 0.5% to 1.5%. If adulteration of the raw milk supply by added water is suspected or detected, then it would be prudent to increase the skim milk powder

addition accordingly, in order to ensure that the final product dry matter meets the specification. The addition of skim milk powder increases the dry matter content of the final product, so enhancing the viscosity. The increased total solids content in the milk improves starter culture growth during the fermentation process. The optimum total solids content is 12-13%.

Homogenisation improves final product viscosity. The milk should be homogenised at 150 bars. This pressure is optimum for viscosity improvement. The use of higher pressures does not improve the final product viscosity, therefore there is no benefit to be derived by using higher pressures.

To ensure consistent product quality, only commercially supplied starter cultures can be used. In this way the product quality will be repeatable on a day-to-day basis and the fermentation will routinely follow an expected progress to completion, so making the timing of the process a matter of routine.

Using a commercial starter will eliminate the presence of wild, undesirable strains whose presence probably cause frequent product failures in makamo currently produced at village level.

Starter cultures

To produce a product similar to *makamo*, the most appropriate culture is a mesophilic *lactic ferment* DL-type culture.

Cultures of this type are supplied by both Ch. Hansen and Wiesby. The typical cultures are CH 11 (Hansen) and Visbyvac Probat 505 (Wiesby). There are several variants of these available, any one of which would be appropriate. The difference between the cultures is the relative proportions of the constituent species of microorganisms.

The culture selected must contain a mixture of *S. lactis* or *S. cremoris*, *S. diacetylactis* and *Leuconostoc spp.* These will provide the production of lactic acid and diacetyl, the primary flavour and aroma compound of cultured milk products.

The culture will halt the fermentation at pH4.55 and there will be no risk of further acidification as is a consideration when processing yoghurt. The fermentation will cease due to the inability of the starter organisms to continue growing below pH4.55. This will permit the product to survive in conditions of inadequate refrigeration and so in terms of ease of process control, is preferential to yoghurt, which continues fermentation to pH3.9 when not stored and handled with effective refrigeration.

Fat Content

The product can be made in a range of fat contents to suit different consumer preferences. Suggested fat contents are 3%, 4.5% and 15%. The latter fat content gives a very heavy viscous cultured cream.

In the Middle East, the product as described below may be packed in sachets as is common in East Africa, but is also widely packed as a set product in a cup. The low fat content version is consumed either by shaking and drinking directly from the sachet or cup or with a spoon from the cup. The higher fat content variations are invariably packed in cups as a set product.

Village Production

Using the method described below, cultured milk may be produced in quantities from 50 litres per day to 500 litres per day. The volume of milk that processed is irrelevant, since the procedures described below are the same no matter the volume of milk processed.

Preparing the milk

For production of good quality cultured milk, good quality raw milk is necessary. This means that the milk should be as fresh as possible and as clean as possible. Never use sour milk.

The milk can be filtered through a very clean muslin cloth. Before using the cloth, immerse it for a few minutes in boiling water, and then remove it from the bucket of water and holding it in the air, allowing it to cool so that you are able to handle it. Never filter milk through a dirty cloth. Dirty cloths contain bacteria and these will transfer from the cloth to end up in the milk.

Preparing the starter culture

Use a good, vigorous starter culture, purchased from a commercial supplier. The most effective method of using the culture is by opening the package and pouring a very few grains of the starter into the milk, after pasteurisation and when the temperature adjusted to the correct incubation temperature.

However, this is also the most expensive method of using the culture. It is possible to extend the use of a packet of culture by using the following procedure.

Put 5 – 10 litres of fresh milk into a milk can. The volume of milk used depends on the number of times a week that you wish to produce the product and the volume of sales. If the intention is to produce the product only one or twice a week, then 2 or 3 litres will be sufficient.

- Place the milk can in a pot of boiling water heated on a fire.
- Stir the milk continuously and heat it to almost boiling.
- Hold the milkcan in the hot water for 20 minutes and then remove it and place the milkcan in a pot of cold water.
- Cool the milk to 25°C - 30°C, stirring intermittently.
- Open the package of culture that you purchased with a pair of clean scissors.
- Pour about a quarter teaspoonful of the granules into milk and stir continuously for not less than 10 minutes.
- Put the lid on the milkcan and close securely.
- Place the milkcan to one side and allow it to stand, undisturbed overnight.

Next morning, look in the can and you will find that the milk has coagulated. This is your starter to be used for a number of productions. It will be good for several days. Ideally it should be stored in a refrigerator, but if a refrigerator is not available, just keep it as cool as possible. Keep the starter clean, by only opening the can when removing starter to use for making the product.

Use approximately 0.3 litres (300 milliliters) of starter for every 10 litres of cultured milk that you make.

All equipment and utensils used for manufacture must be clean and sanitised before use.

- To a bucket of hot water, add detergent powder. The water should be as hot as possible, but not so hot that you cannot put your hand into it. The temperature will be approximately 50°C.
- Using a brush, scrub all the equipment thoroughly, removing any residues remaining from previous use.
- Rinse the equipment in clean water to wash off the detergent.
- Rinse again in a sanitizing solution.

Preparing a Sanitizing Solution

A solution of water and household bleach, Jik, can conveniently be used for sanitizing equipment.

To 10 litres of water, add 0.10 litres (100 mls) of Jik. Use this solution to rinse all the equipment, containers and utensils.

If you are not ready to start preparing the product, invert the containers on a shelf or table and allow to drain. Do not dry the equipment with a cloth.

Processing Cultured Milk

Collect the filtered milk in a clean milkcan.

- Pasteurise the milk by placing the milkcan in a pot of boiling water on a fire.
- Heat the milk to 85-90°C and hold it at this temperature for 20 minutes.
- Remove the milkcan to a pot of cold water and cool the milk to 25-30°C.
- Using a clean, sanitised jug or other suitable utensil, take 300 mls of starter culture from the starter culture milkcan and pour it into the pasteurised and cooled milk.
- Stir the culture in the milk thoroughly for 2 or 3 minutes.
- Put the lid on the can and place the can in a shady place.
- Allow the milkcan to stand overnight for approximately 10 hours.
- After 8 hours remove the milkcan lid and examine the milk. It should have coagulated. If it has coagulated but is not yet firm, then leave it for a further 1-2 hours.
- If whey has collected on the surface of the milk, then the product is ready for packaging. Try and time the incubation to finish before whey collects on the surface.
- The coagulum should be firm, and without cracks and surface whey.
- If you have a refrigerator then put the milkcan into the refrigerator for a few hours to cool. Alternatively, place the milkcan in cool water.
- Using a plunger, cooking spoon or a sanitized paddle, break the coagulum and stir the coagulum gently to get a smooth consistency.
- Pack the finished product into pouches or cups for retail marketing.
- Store the packages in a refrigerator until sale.

It is important to carry out the packaging stage as cleanly as possible and to prevent contamination. This requires that the persons doing the packaging wash their hands in hot detergent water, rinse in clean water and then rinse again in sanitizing water (water with Jik added as described above).

The packaging material must be kept clean and protected from dirt and contamination.

The persons doing the packaging should wear clean clothes.

It is possible to also prepare the product sweetened and with different flavours. If you wish to do this then the sugar must be added to the milk before pasteurisation. This is because the sugar itself carries bacteria and yeasts and these must be destroyed by the pasteurisation process, otherwise they will grow in the final product and produce gas and shorten the shelf-life of the product.

The amount of sugar that should be added is approximately 7%, but this can be adjusted according to customer preference. Food colours and flavours can be added as required.

It is possible to improve the viscosity of the product by adding corn starch to the raw milk before pasteurisation. The quantity of starch can vary, but will be approximately 0.3%. A better, though more expensive solution is to buy a commercial yoghurt stabilizer and to add it to the raw milk in a similar way, at a dosage rate of approximately 0.1%. The advantage of using starch is that it is very cheap and easily purchased.

Factory Processing

In a dairy plant, the process can be controlled effectively and accurately. The advantage of processing in the plant is that the technological parameters can be more tightly monitored and controlled.

The same basic principles of cleanliness, hygiene and sanitation apply, as for production at village level.

The Process

To achieve a more viscous product, the milk should be fortified by adding 1-2% skim milk powder. The addition of powder will also serve to replace any added water that may be present in the milk.

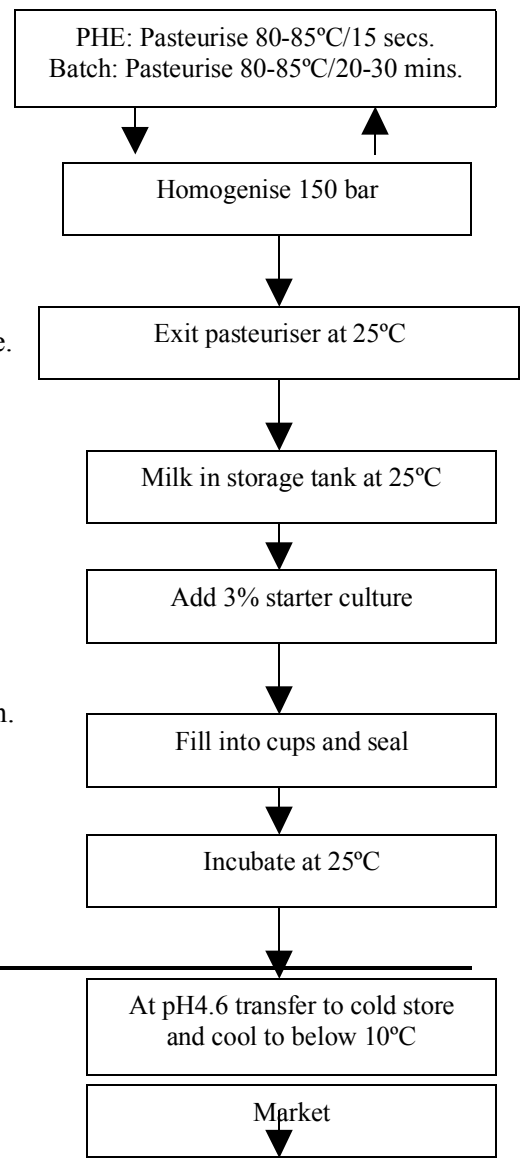
Homogenise at 150 bars, 2-stage homogeniser, with 100 bars on the first stage and 50 bars second stage. If using a single stage homogeniser, then operate at approximately 130-150 bars if possible. There is no technological benefit from homogenising at higher than 150 bars. It is simply more expensive in terms of electricity consumption.

Pump the milk to a tank.

Add the starter culture and agitate for 5 minutes.

Start filling and sealing immediately after adding the starter. Measure the acidity and pH of the milk at the time of starter addition. The pH will be approximately 6.7, acidity 6.0°Soxhlet Henkel (0.15% lactic acid).

Transfer the filled cups to an incubator at 25°C. Allow the cups to incubate undisturbed for 4 hours, then draw a sample from the incubating cups and measure the pH and acidity.



From 4 hours, the acidity will advance by 4°S.H. (0.14% l.a.) per hour until attaining a final acidity of 32-34°S.H. (0.8% l.a.) or pH4.6.

Check the increase in acidity every 1 hour after 4 hours incubation and subsequently every 30 minutes until the final acidity is reached.

In parallel examine the product in the cups to assess the degree of coagulation. When the coagulum is firm, and before whey begins to accumulate on the product surface, transfer the batch of product to refrigeration.

Cool overnight to below 10°C before distributing and marketing.

Troubleshooting

The key to successful production is working with sanitised, clean equipment.

Contamination of the product after pasteurisation is the main problem that will affect product quality. Undesirable bacteria that get into the milk will grow in the product and their presence will be seen in several ways.

Cups or pouches of product ‘blowing’

The appearance of swollen packs of product is always due to the presence of microorganisms that should not be present. The bacteria enter the product when it has been contaminated by being left exposed e.g. lids not replaced on cans of product, or packaging workers having dirty hands, sneezing, coughing spitting close to exposed product.

Gas production causes the packs/cups to swell. The gas that causes the swelling is carbon dioxide and is nearly always due to the presence of yeasts. Yeasts are found everywhere in Nature, especially on plants, animals, clothing. They produce carbon dioxide and as it builds up in the pack, it causes blowing.

The remedy is to work cleanly and to sanitise all utensils before use in sanitizing solution. Storing the product in a refrigerator does not eliminate the problem, it only slows down the growth rate of the yeasts.

Gas holes in the product

Gas holes in the body of the product are due to another microorganism called coliforms. Coliform are intestinal bacteria that live in the human and animal gut. Their presence in the product indicates gross contamination due to working in an unsanitary manner.

Again the solution is to clean up the work area, the utensils and the work routines.

Product not sufficiently viscous

The manufacturing process at the village level as described above is difficult to improve on. The only effective solution for improving viscosity is to use either a stabilizer, which will effectively increase the viscosity to any desired degree, or to add starch to the milk. Starch will change the texture and mouthfeel of the product slightly, but careful adjustment of the quantity used will enable an acceptable final product that will meet customer expectations.

Surface moulds appearing on product

Surface moulds may appear on the product a few days after packaging. They will appear only in product that has been packed in cups and are set. They will not appear in product packed in pouches.

The presence of surface moulds is a key indicator of post-pasteurisation contamination and again the remedy is to revise the work routines and to take care that all procedures are carried out in as clean and sanitary fashion as possible.

References

1. Sserunjogi, M., (1999), Ugandan Indigenous Fermented Dairy Products, with Particular Focus on Ghee. Dept. Food Science, Agricultural University of Norway.