Possible Interventions in Butter & Liquid Milk Processing by the EDGET project, Addis Abeba, Ethiopia

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LIVESTOCK RESEARCH
WAGENINGEN UR

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This research was conducted by Wageningen UR Livestock Research, commissioned and funded by the Ministry of Foreign Affairs via the Embassy of the Kingdom of the Netherlands in Addis Abeba and SNV Ethiopia

Wageningen UR Livestock Research
Lelystad, July 2014

Livestock Research Report 772

Francesca Neijenhuis, 2014; Lelystad, Wageningen UR (University & Research centre) Livestock Research, Livestock Research Report 772.

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Summary

As part of the Enhancing Dairy Sector Growth in Ethiopia (EDGET) project, the objective of this report is to identify and prioritize interventions in the butter and liquid milk chain that will improve marketing of milk by farmers and farmer groups.

Based on several in-depth discussions with the project team and other development partner in Ethiopia, a field visit of one day, a literature review and the input of a consultant the following overall conclusions and recommendations were formulated:

- Milk and dairy product yield, shelf life and food safety issues are closely related to low milk quality. It is advised to put effort into increasing milk quality on farm and within the chain of milk handling & processing.
- Within the butter chain and liquid milk chain there are several areas with opportunities to improve quality, efficiency and thus yield. We advise project management to select a number (about three) of the most promising options for further exploration and evaluation. In this development process proper experimental procedures will need to be observed, including piloting and scaling on an increasing scale of production.
- The plans for development of the EmBwa yogurt drink need careful exploration, as the related technological challenges and safety concerns necessitate involvement of a risk-carrying private party, with observance of product development process, testing, and product approval.
- We recommend that the project contracts the services of a local consultant with applied knowledge on milk quality and milk processing in Ethiopia, who can give added value to the milk processing objectives.

1 Background

In December, 2012 the Embassy of the Kingdom of the Netherlands (EKN) signed a funding agreement with the Government of Ethiopia and SNV-Ethiopia for a dairy development project in Ethiopia. The Enhancing Dairy Sector Growth in Ethiopia (EDGET) Project is building on the experience of the SNV BOAM project (2005-2011) and WUR/SNV MIDD Project (2011-2012).
The main goals of EDGET are

1. Increased dairy income
2. Improved nutritional status of children.

EDGET's objectives are defined as:

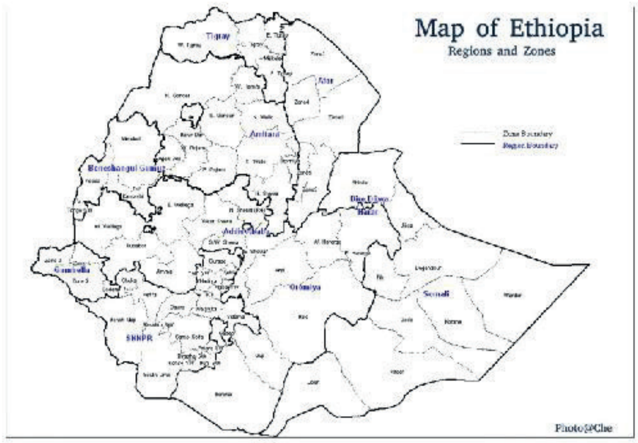
1. To enhance sustainable dairy production and productivity, input supply and related services
2. To increase marketing of dairy products, particularly for children under-3
3. To contribute to development of institutions and to sector-wide initiatives.

This report is designed to contribute to achieving the above objectives in general, and in particular "to increase the volume and quality of milk marketed by targeted farmers" (result area 1) and "to increase the quality and diversity of processed dairy products, in response to nutritional needs" (result area 2). The possibilities presented were explored during the "exploratory mission" of one week with one field day in January, 2014 (see annex 3).

The objective of this report is to identify and prioritize interventions in the butter and liquid milk chain that will improve marketing of milk by farmers and farmer groups. This could include design and manufacture of low tech, manual and off-grid dairy processing equipment, particularly cream separators and butter churners and yogurt making processes based on skimmed milk; extended "shelf-life" of milk and dairy products using chemical alternatives to a cold chain. Technologies may include:

- Hot-holding of milk
- in packet pasteurisation of whole milk
- turning yogurt (ergo) into cottage cheese (ayeb)
- producing EmBwa
- other butter chain interventions.

2 Introduction to the field



EDGET is aimed at dairy development in the production systems within 51 woredas (within the Oromya, Amhara and SNNP regions). Dairy farmers are mostly smallholders (1 – 4 cows).
In these production systems, types of dairy products produced include fresh milk, ergo (naturally fermented milk, kind of yogurt), butter (sweet and sour types), ghee, and ayib (cottage cheese).
There are two marketing systems in the central highlands of Ethiopia: the formal system in which the milk is collected from milk collection centres at the roadside and taken to small to medium-scale processing plants; and the informal system where smallholder producers sell their surplus produce to their neighbours or in the local market, either as liquid milk or in the form of ergo, butter, and/or ayib. Sales of dairy products, especially butter, contribute to the rural household income in the Ethiopian highlands. Butter is the most marketed commodity because of selling price and shelf life. During fasting days (up to 200 days a year) no dairy products are consumed and shelf life of the dairy products is therefore important.

3 Milk quality and dairy products

Milk is a nutritious food with many essential nutrients that contribute to the proper functioning of the body and that are relevant for maintaining good health during all ages and stages of life. But milk can be a potential cause of food poisoning if not adequately processed. In all dairy processing it is essential that full and proper hygiene precautions are taken to ensure the safety of the products. The milking procedure, subsequent bulking, and the storage of milk carry the risks of further contamination from man or the environment or through growth of inherent pathogens.
Ethiopia is reported to have the world's fifth largest number of child deaths each year due to diarrhea (UNICEF/WHO 2009). It is not known which proportion of these diarrheal cases is caused by consumption of milk and dairy products. However, it is common practise to consume raw milk and traditional non-heated sour dairy products.
As stated by Yilma (2012) the highest ranking constraints for milk quality in his study in Ethiopia are limited awareness on hygienic handling and shortage of capital, followed by lack of clean water and poor type of barn.

Table 1
Major milk quality related problems ranked using pair-wise comparison during group discussions (Yilma 2012)

Constraints	Rank
Limited awareness on hygienic handling	1^{st}
Shortage of capital	1^{st}
Lack of clean water	3^{rd}
Poor type of barn	3^{rd}
Hygiene of the milker	5^{th}
Lack of transport facilities	6^{th}
Mastitis	7^{th}
Inappropriate materials used for dairy production and handling	8^{th}

The microbial properties of milk and dairy products in Ethiopia are generally much higher than the acceptable limits in the EU (Council Directives 92/46/EEC and Regulation (EC) No 853/2004). Raw milk in the EU should have a total plate count of <100,000 cfu/ml (10^5). Some recent bacteriological findings in literature of the total plate count (TPC) of raw milk in Ethiopia are 2.45 x 10^7 cfu/ml (Shunda et al. 2013), 9.62 x 10^5 cu/ml (Tolosa 2013), or in the range of 3.5 x10^5 to 4.6x10^6 cfu/ml in raw milk (Mirkana 2010). In pasteurised milk at main processing plants in and around Addis Abeba bacterial counts of 1.2 x 10^4 to 5.2 x 10^5 cfu/ml were found (Mirkana 2010).

The number of coliforms found in milk is an indicator of poor hygienic condition during milk handling. Coliform bacteria include the organisms *Escherichia coli* and *Enterobacter aerogenes*. Coliforms can cause rapid spoilage of milk because they are able to ferment lactose with the production of acid and gas, and are able to degrade milk proteins. Coliform count as accepted in Europe is < 1 cfu/ml for Enterobacteriaceae in raw milk, <10 cfu/ml for coliform in pasteurised milk, and <100 cfu/ml for coliform in raw milk intended for direct consumption (Council Directive 92/46/EEC of 16 June 1992). Coliforms are found in higher numbers in raw milk in Ethiopia. At processing centres in Addis Abeba the coliform count ranged from 3.73 x 10^4 cfu/ml to 6.67 x 10^5 cfu/ml in raw milk samples (Mirkana 2010). Tolosa (2013) reported a coliform count of 2.26 x 10^5 cfu/ml in raw milk at farm level in Yimma town (south western Ethiopia)(Tolosa 2013). Mirkana (2010) found *E. coli* at different plants ranging from 4.33 x 10^4 cfu/ml to 5.37 x 10^5 cfu/ml in raw milk and 0 to 2.2 x 10^4 cfu/ml in pasteurised milk (Mirkana 2010).

Birhanu et al (2013) reported microbial quality of ayib of open market vendors around Jimma. They found a total bacterial count of 6.98 x 10^8, coliform count of 5.12 x 10^5 and Enterobacteriaceae of 3.19 x 10^6 cfu/gram of ayib (Birhanu et al. 2013). The European norm for coliforms in soft cheese (made from heat-treated milk) is <10^5 cfu/g (Council Directive 92/46/EEC of 16 June 1992).

Other important criteria for raw milk and soft cheese are counts of *Listeria monocytogenes*, *Salmonella*, *S. aureus,* and *E. coli.*

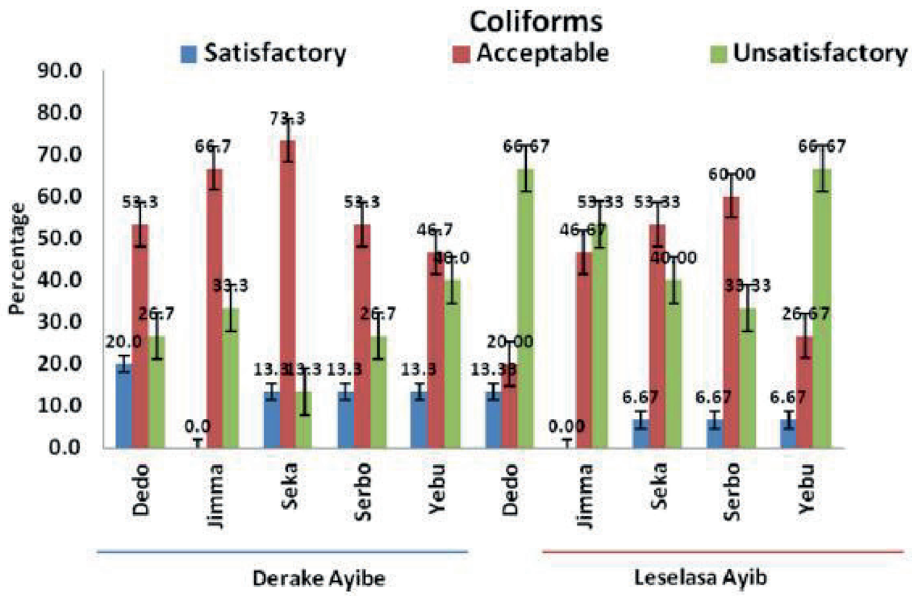


Figure 1 *Coliforms count standardization in percentage according to the Council Directive 92/46 EEC, 1992 standard of soft cheese made from heat-treated milk. Figure based on 150 randomly selected samples of soft cheese (ayib) collected from five vendors of open market places at Jimma town and its surrounding districts. Satisfactory if the count is ≤10'000 cfu/g; unsatisfactory if the count is ≥100'000 cfu/g; acceptable between 10'000 and 100'000 cfu/g. (Birhanu et al. 2013)*

Preservation methods for milk (products) that are potentially suitable for smallholders are normally cooling (to extend the shelf life of fresh milk by a day or two), heating (pasteurisation, sterilisation to destroy enzymes and micro- organisms) and acidification (to inhibit spoilage or food poisoning bacteria from growing). Most farmers in the highlands of Ethiopia do not have access to electricity (off-grid areas) or clean water. 'Spontaneous' fermentation, and thus acidification, is the common preservation method used by farmers in Ethiopia. Natural fermentation results in sour milk and prevents milk from getting spoiled by other pathogens. Natural fermentation takes 1½ to 2 days. Fermentation time is affected by temperature and some other factors. For example, it seems that smoking of milk vessels will slow down the fermentation process. It should be noted that this natural fermentation process seems to be of importance to reduce the risk of staphylococcal poisoning from consumption of informally-marketed milk and home-made yogurt (Makita et al. 2012).

Traditional butter-making within the informal butter chain in the highlands of Ethiopia is based on fermented milk (ergo); milk that has been accumulated over a few days and left fermenting, commonly in a clay pot. When the milk has soured and sufficient milk has been collected, the clay pot is shaken until butter granules are formed. This method of butter making may take from two to five hours, depending on such factors as temperature, the fat content of the milk, the acidity of the milk and the amount of milk in the clay pot. According to Yilma and Ledin (2000) traditional butter making requires about 21-25 kg milk to produce 1 kg of butter with moisture content of 83%, from the remaining buttermilk 3.2-4.5 kg Ayib can be produced. Butter making using an internal agitator and improved technology requires 20kg and 16-18kg of milk respectively to produce 1 kg of butter (Yilma and Ledin 2000).

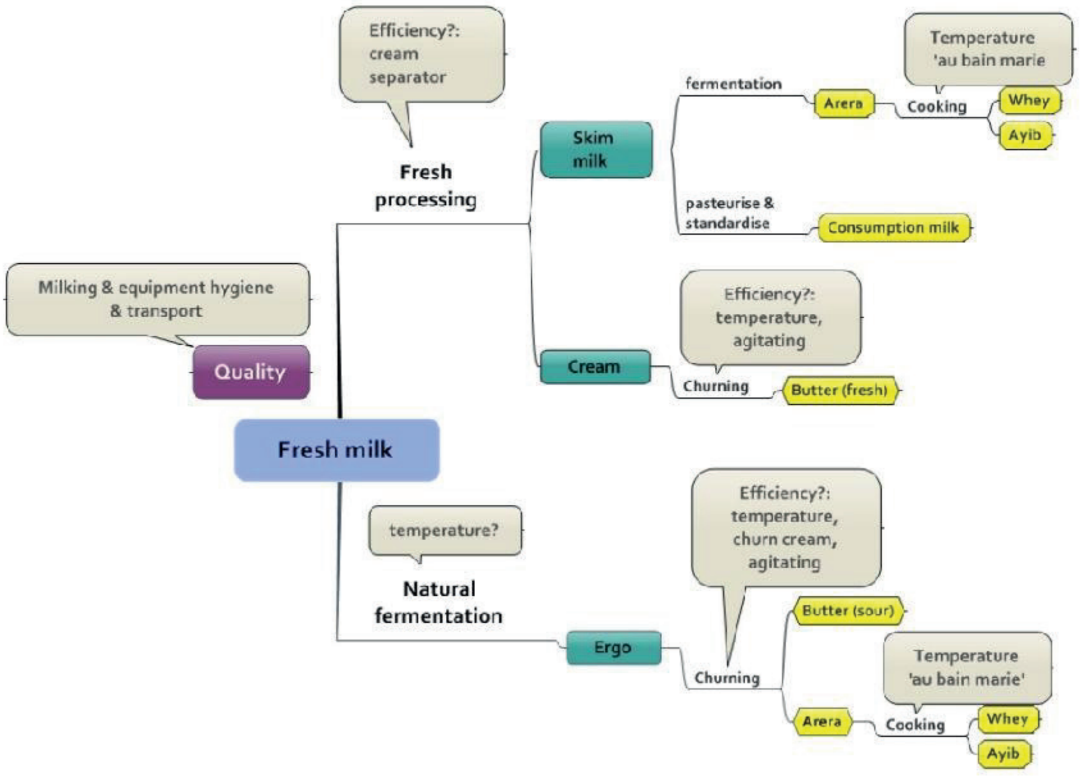


Figure 2 *Schematic overview of processing steps from raw milk into traditional and not fermented products. Indicated are the possible steps of improvement.*

The left over product of butter processing is defatted (sour) milk (skimmed milk or buttermilk (arrera)). This is used to make a kind of cottage cheese called ayib. The casein and some of the unrecovered fat in skimmed milk and buttermilk precipitate by heat. The defatted milk is heated to 50 - 70°C until a distinct curd mass forms. It is then allowed to cool gradually and the curd is ladled out. Ayib is mostly consumed

4 Options for improvement

4.1 Options for improving the quality of milk collected

The overall purpose regarding improvements within the butter and liquid milk chains is to enhance dairy product quality and shelf life. Increasing milk quality within the chain has the potential to enhance product quality and shelf life. Current practices in pasteurisation of milk do not seem to lower the total bacterial count or the coliform count to levels considered "safe" in Europe. Improving milk handling and processing starts with handling of milk on-farm.

Options for improving milk quality include:

- ***Increase awareness and technical skills on hygienic milking (including clean equipment and transport) using effective translation of knowledge to practice.***

  It is recommended to focus extension services on hygienic milking (hygiene of cow, shed, hands and equipment). This could include:
    - Explore (re)introduction of this subject through (existing) extension services within the 51 target woredas and by using the dairy collection by cooperatives and farmer groups.
    - Explore possibilities to cooperate with or use available material on this subject from other organisations or projects like FAO, ILRI, Land O' Lakes, GAIN, and HOPE.
    - Bring knowledge to practice and focus on the barriers to adoption of quality improvement practices (risk perception, ability to adopt improved practices, social and cultural factors affecting adoption of new practices).

- ***Offering cleaning facilities of milk containers after delivery of milk***
  With cleaning facilities it can be avoided that empty uncleansed containers are transported back to the farm, where insufficient water may be available to clean properly. This may be accomplished by building an easy to use cleaning place and by providing clean water and cleaning materials at the milk collection centre.

- ***Stimulate the use of clean milk containers with reduced contamination routes***
  Explore the use (availability/price, sealability, life span, practicality, acceptance, hygiene) of i) rounded stainless steel containers with wide neck and ii) plastic containers.



  Wide neck aluminium (or comparable material) containers may decrease the risk of microbial contamination because they can easily be drained upside down and partly disinfected by using the sun to warm them (thermal disinfection). In a study in Tanzania it was found that the use of wide neck aluminium containers by famers and milk transporters, as compared to wide neck plastic containers, decreased the risk of high bacterial contamination of the milk (Shija 2013). The container should be used to milk (height and other practical issues) and transport of milk.

Avoiding the use of separate containers to milk and transport the milk may increase milk quality by skipping additional contamination routes. The lid should seal the container to avoid dripping during transport and avoid the use of plastic constraints within the inner lid. The milk container should be easy to clean: no internal edges, smooth internal surface, accessible to clean, and the material should be food safe. Contamination of the inner side of the lid should be avoided during milking and transfer of milk.

- ***Motivate farmers to improve quality of milk by quality based payment***
  In addition to, or after, offering extension services and materials to increase milk quality, introduction of a quality based payment system at the milk collection centres may motivate farmers to increase the quality of the milk. Milk collection centres can use the alcohol and gravity tests at each milk delivery to decide whether to reject the milk. A next step may include differentiating the milk payment based on total bacterial count and/or fat content.

4.2 Options in the butter chain

Possible innovations to increase the (informal) butter chain, in terms of yield and income, may be found in increasing fermentation speed, churning efficiency, or shelf life, and in processing ayib and other products with added value.

Further interventions to improve butter yield and ayib quality worth considering include:

- **Possibilities to speed up the natural fermentation process**
  There is a need to investigate the speed of fermentation, in relation to milk fat recovery and shelf life of butter. On this subject, contact with Dr. Almaz Gonfa of the EPHI (see annex 4) may result in better knowledge on the natural fermentation process and possible improvements.

- **Further possibilities to increase churning efficiency**
  Churning efficiency is measured in terms of the time required to produce butter granules and by the amount of milk fat recovered in the form of butter. The efficiency is affected by temperature, the fat content of the milk, the acidity of the milk, the agitation method, and the volume of milk in the pot. Churning improvements may be achieved by:
    - **Churning only cream**. First separate the cream from the sour milk and only use this part within the churning process. As naturally fermented milk is not liquid anymore, this may require other equipment than the cream separator used in sweet butter preparation.
    - **Introducing an agitator**. A mechanical churner is used in some milk collection centres that process the milk. When such a churner is not affordable or processed milk yield is low, a simpler agitator may be introduced. The technology developed by ILCA (internal agitator), improves churning ((O'Connor 1995). Investigate if such an (adapted) agitator can be used in (small) milk collection centres or at the farm (availability & cost, feasibility, acceptance), and if a more sturdy and low cost alternative to the wooden agitator of ILCA could be developed.
    - **Cool milk before churning**. Cooling of milk before churning to temperatures around 18°C will improve fat recovery. Investigate if milk cooling is possible (for example using evaporative cooling) and if the increase in churning efficiency makes this a practical and affordable (price of cooling, time consumption) improvement. Farmers in some locations may already practice this.

- **Marketing opportunities for sweet butter**
  In a departure from traditional practice, collective milk processing by farmer groups and cooperatives often switches to production of sweet / cream butter from unfermented milk. Sweet butter usually is only purchased for cosmetic purposes. While the advantage of sweet butter is that milk can be processed right away, the disadvantages of having to process right away, limited market demand, and reduced shelf life as compared to sour butter, necessitate additional attention to marketing opportunities.

- **Improving the production of ayib**
  Ayib has normally a short shelf life as bacteriological contamination is high. Processing optimisation may increase the food safety and shelf life of ayib. This may include:
    - Optimal temperature of arrera 'au bain marie' treatment (indirect heating) to ensure best quality Ayib. Investigate whether better temperature control of the wood-fired water bath will improve the quality of the ayib. Explore temperature measurement that suits the practice on smallholder farms and milk processing centres (70°C for 55 min / 60°C for 145 min): inexpensive, reusable and easy to use.
    - Reduce water content of ayib. Shelf life of ayib may be lengthened by adding salt, reducing the moisture content of the cheese (optimise heating, pressing, or filtering the cooled mixture through a cloth) and by storing the product in an airtight container.

- **Other products with added value**
  The project is looking for possibilities to process EmBwa - a low tech processed yogurt of skimmed milk, fortified and with added palm oil - as a nutritional product for children to achieve less malnutrition. The conditions stipulated by the project manager are:

  "decentralised production close to the milk suppliers; does not require a cold chain; within the set target price of USD $ 0.15 and USD $ 0.25 for 125 ml and 250 ml respectively; marketing of this product should take place in the 51 plus rural woredas targeted by EDGET (within the zones Oromiya, Amhara and SNNP regions) through a network of female informal sellers / hawkers who will be trained in basic nutrition principles and supported to develop a clientele in a designated village or neighbourhood on a door- to- door basis; the product should have a shelf life of 7 days in the highlands, without a cold chain."

  For this product development process WUR was asked to advise the project leader on request by selecting and suggesting appropriate consultants. From a food processing and food safety point of view the consultant Kees Daamen was asked to write an advice on the following topics of EmBwa processing possibilities:
    - Shelf life: 1) Explore the relationship between the quality of the raw milk, skimmed sour milk and the expected food-safety and shelf life (spoilage by bacteria, fungi, yeast and/or viruses) of the foreseen fermented yogurt.
      2) Investigate the use and (low cost) availability of bactericides/preservatives in the raw milk and processed product (to destroy or inhibit the action of enzymes and contaminating bacteria).
    - Adding palm oil: 3) Explore the availability of low cost emulsifiers that can be used (DSM, DVM, consultants).

  The report of the consultant can be found in Annex 1. The main conclusions:
  a. Microbiological quality of the raw milk and arrera (the starting product for EmBwa) often is low. Decrease of the pH of the product by natural fermentation does not overcome the problems with (all) possible food-born problems. Particularly arrera, which is not or insufficiently acidified (pH >5.5), should not be used for EmBwa because of high pathogenic risks.
  b. Adding oil, fortification, bactericides and emulsifier to arrera under field conditions found in Ethiopia may lead to further contamination of the dairy product.

c. Bacteriological quality and shelf life of EmBwa, as a modified product of arrera, without additional treatment will not be satisfactory.
d. An alternative may be adding complementary food supplements (also called in-home fortification of complementary foods) to the traditional (defatted) fermented milk. This procedure requires less processing steps and makes it possible to use fresh arrera.
e. It may be worthwhile to advice farmers to serve their children fresh and cooked milk directly after milking. This short route from cow to child, and adding the heat treatment, will result in more safe nutrition. It is advised to compare the foreseen nutritional benefits for young children of milk, traditional fermented dairy products, and EmBwa.
f. The undisputable poor bacteriological quality of the raw material arrera and the absence of cooling facilities make it irresponsible to bring a product on the market where life of children is at risk.
g. Good Manufacturing Practices in dairy production are only guaranteed by starting with at least pasteurised milk free from pathogenic bacteria.

Marianne van Dorp’s mission report on the Nutrition Aspects in the EDGET Project explores the nutritional feasibility of the foreseen EmBwa.

4.3 Options in the liquid milk chain

Possible innovations within the liquid milk chain worth considering may include:

- ***Increase raw milk quality from farm to processing facility (see above)***
  Quality of milk should be kept as high as possible within the collection centre and during transport. Cooling is advisable. Another option is using lactoperoxidase or LP system as stated by the FAO, which is used in many places were cooling of the milk is not an option (FAO 2005).

- ***Advise consumers to boil raw milk before consumption***
  Explore the current situation with respect to the consumption of raw milk at the farm and by other consumers within the informal liquid milk chain. If raw milk is not boiled before consumption it should be considered to inform the consumer to raise awareness on possible health hazards.

- ***Explore possibility of milk cooling in off grid area***
  A company named Mueller has installed a solar cooler in Ethiopia (in test phase) as part of a 'Base of the Pyramid Innovation centre' project. It may be a promising route to cool milk in rural areas where proper (cooled) transport from cooler to factory can be assured as well. For example, the transport of milk on ice from the farm to the MCC may be an option. Ice cubes could be made and provided by the milk collection centre to cool the milk from the next milking during transport.

- ***Explore the feasibility of hot-holding tank for transport***
  Determine the quality and temperature of added milk and milk within the hot holding milk tank, to minimise the risk of curdling of milk. Explore the necessity of stirring the milk within the tank, starting with the results written in the report of Liu (2012) and if necessary get in contact with David Keogh (Global Good) for more information (Liu 2012). Explore the processing quality of the milk transported in the hot holding tank from farmer to the processing centre.

- ***Explore the technical possibilities of using an in-sachet pasteurisation of milk***
  Milk sold in sachets is an accepted route to the consumer in Ethiopia. Pasteurisation of the milk within the final packaging will prevent contamination of milk within the packaging phase. Some cooperatives/processors in Ethiopia already use this technology, marketed under the South African brand of MilkPro. The affordability and feasibility of in-sachets pasteurisations should be reviewed (economic and technical feasibility of quality improvement under local conditions).

5 Overall conclusions & recommendations

- Milk and dairy product yield, shelf life and food safety issues are closely related to milk quality
- Within the butter chain and liquid milk chain there are several areas with opportunities to improve quality, efficiency and thus yield. We advise project management to select a number (about three) of the most promising options for further exploration and evaluation. In this development process proper experimental procedures will need to be observed, including piloting on an increasing scale.
- The plans for development of the EmBwa yogurt drink need careful exploration, as the related technological challenges and safety concerns necessitate involvement of a risk-carrying private party, with observance of product development process, testing, and product approval.
- We recommend that the project contracts the services of a local consultant with applied knowledge on milk quality and milk processing in Ethiopia, who can give added value to the milk processing objectives.

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Annex 1 The possibilities for processing EmBwa

Author: Kees Daamen (consultant)

1. Objectives
To explore the possibilities of processing EmBwa.

2. Introduction
The project is looking for a low tech processed yogurt of skimmed milk, fortified with added palm oil as a nutritional product for children to achieve less mall nutrition, called EmBwa.
The given settings on the product development of EmBwa from the project leader are: decentralised close to the milk supplies and do not require a cold chain, within the set target price of USD $.15 and USD $.25 for 125 ml and 250 ml respectively. Marketing of this product should take place in identified 51 plus rural woredas (within the zones Oromya, Amhara and SNNP) through a network of women informal sellers who will be trained in basic nutrition principles and supported to develop a designated village or neighbourhood on a door to door basis EmBwa will be sold by cup. This product should have a shelf life of 7 days in the highlands without a cold chain.

3. Topics to be addressed
To explore the possibilities of developing EmBwa the following topics are being addressed in this note:

- Product safety and shelf life
- Use of emulsifier

Aspects of nutritional value of palm oil and fortification fall outside the scope of this report.
As input for this report, literature, authors experience, and the report of Neijenhuis are used.

4. Milk quality, product safety and fermentation
The quality of raw milk determines greatly the quality of the processed dairy products like yogurt. Achieving a safe final product from raw milk to the point of consumption requires a combination of control measures that together should achieve the appropriate level of health protection.
According to the literature, the microbial properties of the milk produced by smallholders in decentralised rural areas in Ethiopia are generally much worse than acceptable limits in Europe (Council Directives 92/46 EEC, 1992). The numbers imply that the sanitary conditions in which milk has been produced and handled are substandard. Moreover, bacteria that are known to cause food borne diseases, like *E. coli,* frequently are present in the raw milk. Milk collection centres only check on added water (lactometer) and whether it will coagulate on processing (alcohol test, usually indicates changes to the milk due to bacteriological activity). Quality measurements on microbiology do not seem to be performed by farmers or informal groups of farmers.
The composition of many dairy products makes them good media for the outgrowth of pathogenic micro-organisms. Because milk and many dairy products have sufficient moisture content to support the growth of pathogens, temperature and time controls represent key microbiological control measures to control growth throughout the manufacturing process, from the handling of milk to the distribution and storage of perishable dairy products (like pasteurised drinking milk, desserts, and soft cheeses).
In Western culture, the process of making a (non-strained) yogurt starts with heating the raw milk. The milk is first heated to about 90 °C (194 °F) to kill any undesirable bacteria and to denature the milk and whey proteins so that they set together rather than form curds. The milk is then cooled to about 42 °C (108 °F). The second step is to ferment the milk into a sour product with a thicker consistency. Usually yogurt cultures with *Streptococcus thermophilus* and *Lactobacillus bulgaricus* are used. The bacterial culture is added, and the temperature is maintained for 4 to 7 hours to allow fermentation. Fermentation of lactose by bacteria produces lactic acid, which acts on milk protein to

give yogurt its texture and its characteristic taste. The fermentation process increases the shelf-life of the product, while enhancing the taste and improving the digestibility of milk.

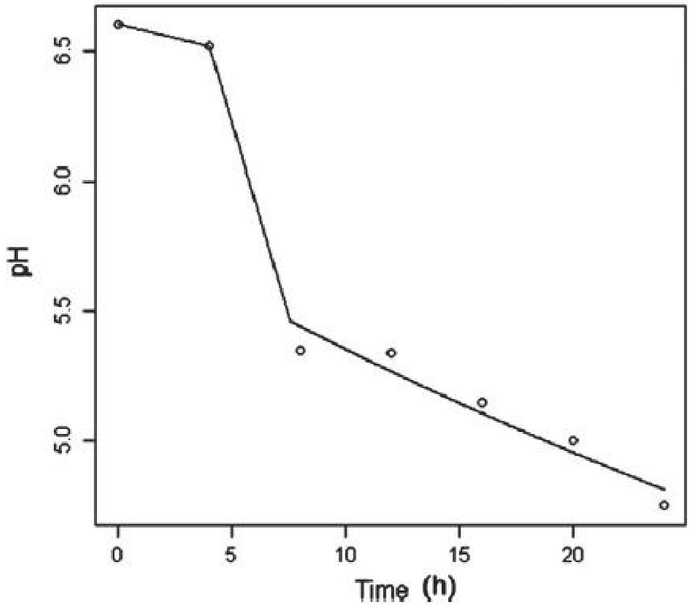

Figure 1 *Data from Gonfa (1999) on decrease of pH of milk during natural fermentation over time.*

In Ethiopia, natural fermentation is used in raw milk to produce ergo, a yogurt-like product. This fermentation process lasts about 2 to 4 days and leads to acidification with a pH of 4.3 – 6.7. Every pH level >4.5 does mean that acidification has been very limited or even no acidification has occurred (pH6.7 is the pH-level of normal milk). As summarised by Yilma (2012) in ergo several LAB genera can be identified: Lactobacillus, Lactococcus, Leuconostoc, Entrococcus, and Streptococcus (Yilma 2012).

Fermentation can reduce the number of undesirable micro-organisms by lowering the pH, consumption of nutrients, and production of bacterial antimicrobial substances (such as nisin, other bacteriocins and hydrogen peroxide). The efficiency is determined by many factors, including the speed and level of pH reduction and variations in the pH level (FAO 2009). A number of foodborne hazards are not affected by lactic fermentation and thus fermentation should not be relied upon for the elimination or reduction of these hazards. In fermenting ergo, *E. coli, Salmonella* spp, *Listeria monocytogenes* may survive, and even *Brucella* has a small chance to survive. In order to ensure food safety, fermentation should therefore be combined with a number of other processing operations, such as cooking or pasteurisation. However, it appears to be generally accepted that without cooling systems and pasteurisation this traditional food preparation by fermentation does reduce the risk of food—borne diseases as compared to raw milk consumption.

5. Plans for EmBwa

Processing EmBwa requires more steps than those used for the traditional soured (skimmed) milk: raw milk would be naturally fermented to become sour milk (ergo), most of the fat would be removed before or after fermenting (to make butter to sell) and the 'left over' arrera (sour skimmed milk) would be supplemented with palm oil and fortification. This mixture will need an emulsifier to make it a stable emulsion. The emulsion is formed by homogenization or blending the arrera and then emulsifying it with the palm oil and other supplements. Bactericides may be necessary to enhance shelf life. During every processing step there will be an additional risk for further bacteriological contamination of the product.

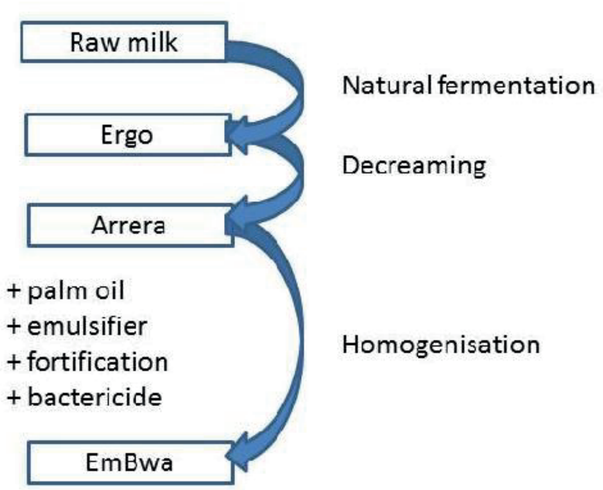

Figure 2 *Steps identified in development of the proposed EmBwa*

Product development of EmBwa starts with defatted ergo called arrera. No data were found on the microbiology, pH or shelf life (in relation to storage time and temperature) of arrera. However, Gonfa (2001) noted that the cottage cheese ayib, that is made from arrera by heating, has a low pH of 3.7 but shelf life is limited to 2 to 3 days (Gonfa et al. 2001). This is (partly) due to the high moisture content of the cheese. Furthermore, in almost half of the samples of ayib yeast were present (proteolytic and lipolytic) and more than half of the samples were positive for coliforms and faecal coliforms.
There are many uncertainties in how well the EmBwa will be stable in terms of bacteriological quality and thus in shelf life.

6. Emulsifier

Adding palm oil to the skimmed (sour) milk may result, after shaking or stirring it vigorously, in a dispersion of oil droplets in water. When shaking stops, the phases will start to separate. Adding an emulsifier to the system may result in a stable emulsion. An emulsifier consists of a hydrophilic head (directed to the aqueous phase) and a hydrophobic tail (directed to the oil phase). By reducing the surface tension, this has a stabilising effect on the emulsion.
Typically used emulsifiers in dairy drinks are lecithin (E322) and mono- and diglycerides of fatty acids (E471). Emulsifiers typically used in yogurt are mono- and diglycerides of fatty acids (E471) and sucrose esters of fatty acids (E473) (EFEMA).

According to the Codex Alimentarius, Milk and Milk Products, second edition only the following emulsifiers may be used (Codex Alimentarius 2011):

INS No.	Name of additive	Maximum level
432	Polyoxyethylene (20) sorbitan monolaurate	3 000 mg/kg
433	Polyoxyethylene (20) sorbitan monooleate	
434	Polyoxyethylene (20) sorbitan monopalmitate	
435	Polyoxyethylene (20) sorbitan monostearate	
436	Polyoxyethylene (20) sorbitan tristearate	
472e	Diacetyltartaric and fatty acid esters of glycerol	10 000 mg/kg
473	Sucrose esters of fatty acids	5 000 mg/kg
474	Sucroglycerides	5 000 mg/kg
475	Polyglycerol esters of fatty acids	2 000 mg/kg
477	Propylene glycol esters of fatty acids	5 000 mg/kg
481(i)	Sodium stearoyl lactylate	10 000 mg/kg
482(i)	Calcium stearoyl lactylate	10 000 mg/kg
491	Sorbitan monostearate	5 000 mg/kg
492	Sorbitan tristearate	
493	Sorbitan monolaurate	
494	Sorbitan monooleate	
495	Sorbitan monopalmitate	
900a	Polydimethylsiloxane	50 mg/kg

An emulsifier suitable for the skimmed sour milk with palm oil drink should be food-safe, stable under local conditions, not adding an opportunity to microbial growth, and processed without high tech equipment. Further requirements set by the project are availability of ingredients in Ethiopia and low cost. Furthermore, adding palm oil and fortification will change the emulsion characteristics and probably the taste, flavouring may be needed.

Advice on emulsifiers that may suitable in processing EmBwa is difficult. Literature shows that there is a large variation in composition and pH of the raw material. Testing different emulsifiers under local application conditions, with available arrera and palm oil, must be carried out in order to find a suitable emulsifier and process conditions.

7. Bactericides

Within fermented milk there will be bacterial antimicrobial substances with an inhibitory effect over spoilage organisms (such as nisin, other bacteriocins and hydrogen peroxide). Particularly hydrogen peroxide (H2O2) is generally accepted in tropical, developing countries without raw milk cooling, proper transport systems etc. H2O2 can be used as a preservative to maintain the holding quality for a longer period of time. However, in respect to an aimed shelf life of 7 days, the dosage and effect of H2O2 must be studied under the local conditions (basic contamination, temperatures in place). This chemical method for preserving milk by activation of the lactoperoxidase system (LP) with hydrogen peroxide may not increase milk quality because the effect is mainly bacteriostatic (Codex Alimentarius 1991) and does not destroy all pathogenic bacteria. The antibacterial efficacy through activation of the LP is found to be inversely correlated to bacterial cell density. Moreover, many dairy cultures are sensitive to the LP-s and may interfere with the fermentation processes (FAO 2005). Moreover, these substances may be changed by adding the oil, fortification and emulsifier.
Next to the mentioned H2O2 no other permitted bactericides for dairy products were found in literature.

To reduce moulds and yeasts in dairy products, natamycin may be used. Natamycin does not have any effect on bacteria therefor it can be used in acid dairy products as it will not affect the bacterial growth/acidification. Furthermore, benzoates and sorbates are permitted additives to inhibit yeasts and moulds and therefore may be found in yogurt (Khurana and Kanajia 2007).

8. Conclusions

a. Microbiological quality of the raw milk and arrera (the starting product for EmBwa) often is low. Decrease of the pH of the product by natural fermentation does not overcome the problems with (all) possible food-born problems. Particularly arrera, which is not or insufficiently acidified (pH >5.5), should not be used for EmBwa because of high pathogenic risks.
b. Adding oil, fortification, bactericides and emulsifier to arrera under field conditions found in Ethiopia may lead to further contamination of the dairy product.
c. Bacteriological quality and shelf life of EmBwa, as a modified product of arrera, without additional treatment will not be satisfactory.
d. An alternative may be adding complementary food supplements (also called in-home fortification of complementary foods) to the traditional (defatted) fermented milk. This procedure requires less processing steps and makes it possible to use fresh arrera.
e. It may be worthwhile to advice farmers to serve their children fresh and cooked milk directly after milking. This short route from cow to child, and adding the heat treatment, will result in more safe nutrition. It is advised to compare the foreseen nutritional benefits for young children of milk, traditional fermented dairy products, and EmBwa.
f. The undisputable poor bacteriological quality of the raw material arrera and the absence of cooling facilities make it irresponsible to bring a product on the market where life of children is at risk.
g. Good Manufacturing Practices in dairy production are only guaranteed by starting with at least pasteurised milk free from pathogenic bacteria.

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Annex 2 Time schedule

Date	Time		Activity
Monday January 20	07.30	hours	Arrival Churchill Hotel, Addis Abeba
Monday January 20	10.00-14.00	hours	Meeting with Mr. Roland Hodson and Mr. Jan Vloet
Tuesday January 21	10.00-11.30	hours	Meeting with Mr. Alem Abay, GAIN Ethiopia
	15.00-17.00	hours	Meeting with Mr. Gerrit Noordam, Embassy of the Kingdom of the Netherlands
Wednesday January 22	9.00-13.00	hours	Working at SNV office
	14.00-16.00	hours	Meeting with EHNRI, various staff members, Contact person Mrs. Aragash Samuel
	17.00-18.00	hours	Debriefing Mr. Jan van der Lee
Thursday January 23	06.30-16.30	hours	Field visit to milk collection centres, smallholder dairy farmers and small-scale milk processing centres north of Addis Abeba
Friday January 24	10.00-13.00	hours	Meeting with Dr Eleni Asmare, FAO Ethiopia Human Nutrition Meeting with Dr Oumer Diall, FAO Regional Office, Livestock officer
	14.00-15.00	hours	Debriefing SNV office
Saturday January 25	09.00	hours	Departure to airport

Annex 3 Field trip

Field trip: Thursday January 23 (6.30-16.30 hours), Oromiya, North of Addis Abeba

During this one day trip, via the main road up from Addis Abeba, we visited:

1. Milk collection centre with no chilling facilities wherefrom the milk is transported to three different processing plants in Addis Abeba. During the visit, farmers brought their milk to the centre and milk quality was checked with the lactometer (gravity check whether water is added) and alcohol (whether it will coagulate on processing).
2. Milk collection and processing plant "Duber Primairy Dairy Cooperative " where milk is processed into cream (cream separation done by hand centrifuge) and butter (churning) and Ergo. Furthermore, the plant processes ayib using 'au bain marie' cooking on wood fire. During the visit butter and ayib were made.
3. Famers (all bringing the milk to processing plant):
    a. 1 cow in the field with 1 calf in the barn
    b. 2 cows with 2 calves in the yard
    c. 4 cows and calves in the field

    During the visit no milking took place.
4. Dairy shed (40 heads in two barns) and milk processing plant to pasteurise milk, processing of soft and hard cheeses. The processing plant has equipment like a pasteuriser, homogeniser, sachets packet (brand Milk Life). During the visit no milking or milk processing took place.

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Annex 5 Terms of reference

Enhancing Dairy Sector Growth in Ethiopia [EDGET]

PLANNING OF BUTTER & LIQUID MILK CHAIN PROCESSING INTERVENTIONS

Terms of Reference for Wageningen UR Livestock Research

No : II.1
Version : 1
Date : January 15, 2014
Developed by: JL

N.B. This is a growing document that may be adjusted over the course of the year.

Contents

EDGET fact sheet

Project title:	Enhancing Dairy Sector Growth in Ethiopia (EDGET)
Duration:	December 2012 to December 2017 (5 years)
Goal:	To improve household income and nutritional status of children through increased dairy production and enhanced dairy processing & marketing.
Expected project impact on:	- Increased dairy income of target farmer households - Improved nutritional status of children
Key targets:	- 65,000 farm households double income from dairy - Increased nutritional status of 500,00 children
Project financing:	- Total budget from Embassy Kingdom of the Netherlands (EKN) in Ethiopia € 10,000,000
Lead organisation and subcontractor	- SNV Netherlands Development Organization Ethiopia - Sub-contractor: Wageningen University & Research centre (Wageningen UR)
Main government counterpart agencies:	- Ministry of Agriculture in Ethiopia – concerned Directorates - Regional Bureaus of Finance and Economic Development - Regional Livestock Development and Marketing Agencies - Private sector (input supply, service provision, production, processing, and marketing)

1. Background

In December, 2012 the Embassy of the Kingdom of the Netherlands (EKN) signed a funding agreement with the Government of Ethiopia and SNV-Ethiopia for a dairy development project in Ethiopia. The EDGET Project is building on the experience of the SNV Dairy Value Chain project (BOAM 2005-2011 and WUR/SNV MIDD Project (2011-12).

The main goals of EDGET are 1. Increased Dairy Income and 2. Improved Nutritional status of children. EDGET's objectives are defined as:

1. To enhance sustainable dairy production and productivity, input supply and related services
2. To increase marketing of dairy products, particularly for children under-3
3. To contribute to development of institutions and to sector-wide initiatives.

2. Objectives and scope

This consultancy is designed to contribute to achieving the above objectives in general, and in particular "to increase the volume and quality of milk marketed by targeted farmers" (result area 1) and "to increase the quality and diversity of processed dairy products increased, in response to nutritional needs" (result area 2).

Its objective is to

- Identify and prioritize interventions in the butter and liquid milk chain that will improve marketing of milk by farmers and farmer groups. This could include design and manufacture of low tech, manual and off grid dairy processing equipment, particularly cream separators and butter churners and yogurt making processes based on skimmed milk; extended "shelf -life" of milk and dairy products using chemical alternatives to a cold chain;
  Technologies may include:
    - producing and packaging EmBwa - methods of fortifying, flavouring and preserving child nutrition products based on skimmed milk; in decentralised locations around Ethiopia, close to milk supplies, without the use of electricity and a cold chain; using bactericides to slow the growth of bacteria; fortify calories through the introduction of palm oil and an emulsifier;
    - in packet pasteurisation of whole milk
    - turning yogurt (ergo) into cottage cheese ("ayeb")
    - hot holding milk
    - other butter chain interventions.
- Define and source the technical expertise that is required to address the technical and logistic bottlenecks associated with the development of this product
- Advise the project manager on additional interventions needed in the value chain.

3. Tasks, requirements and main deliverables

The tasks of WUR consultant are:

No.	Task	Methodology
1	Familiarization visit	- Joint trip with Marianne van Dorp and Jan van der Lee, including field visit showing variety in farmer situations - Discussions with project team on approaches and priorities - Advisory report to project manager
2	Recruit technical experts	- Use network to identify expertise, contract and send to EDGET in communication with project manager
3	Technical advice on queries project team	- Email advice on technical queries - Identify need for additional trips

The main deliverables of WUR are:

- An advisory report detailing feasible intervention options and choices that have to be made by EDGET management, with suggested approach and steps, to be submitted to project leader within 3 weeks after return
- Contracting of up to 3 technical consultants
- Technical advice on queries project leader.

4. Time table

- Familiarization visit January 2014
- Consultants to be contracted over course of next 6 months

5. Resources

- 10 day trip Dr Francesca Neijenhuis January 2014, including ticket, hotel and DSA, plus 4 days to finalize advisory report
- 3 days per contracted consultant for identification, contracting, briefing and debriefing
- 10 days for technical queries.

6. Rules of the game

- EDGET and WUR will keep open communication lines in order to come up with good advice
- When one of the parties is not satisfied with the results, direct consultation should be sought for
- Each party tries to react as soon as possible to proposals, feedback and results.

To explore the potential of nature to improve the quality of life

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Livestock Research Report 772

Together with our clients, we integrate scientific know-how and practical experience to develop livestock concepts for the 21st century. With our expertise on innovative livestock systems, nutrition, welfare, genetics and environmental impact of livestock farming and our state-of-the art research facilities, such as Dairy Campus and Swine Innovation Centre Sterksel, we support our customers to find solutions for current and future challenges.

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