Traditional butter making in Ethiopia and possible improvements

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Summary

FEW FARMERS IN *the Ethiopian highlands have a ready outlet for their surplus liquid milk; the majority can only market products with greater storage stability. A survey of traditional butter making in the Ethiopian highlands has revealed that both the equipment and the methods currently used are inefficient. Traditional churning is time consuming and labour intensive, and results in considerable losses of fat in the buttermilk.*

Experiments carried out with a traditional clay pot churn fitted with an internal agitator indicate that as much as 90% of the fat can be recovered from whole milk. Internal agitation also reduces the time needed for churning, making the process more efficient and reducing labour requirements.

Separating the cream from the milk by surface skimming or by centrifugal separation improves fat recovery considerably, but both methods have certain drawbacks in respect to smallholder dairying. Gravitational separation is not feasible with the small quantities of milk retained daily by producers for processing, and the machinery used for centrifugal separation is too costly for the individual farmer to purchase. However, centrifugal separation could be economic if a number of farmers pooled their milk to accumulate an adequate volume. Cream from 100 litres of milk could be processed daily into butter by combining centrifugal separation with the improved earthenware churn.

Introduction

The typical Ethiopian highland farm produces a small surplus of milk for sale. Farmers close to main roads within 120 km of Addis Ababa have no marketing problems: they can sell their milk directly to consumers or to traders, as well as to the Addis Ababa dairy industry through an established milk collection system. Elsewhere in Ethiopia, farmers near towns generally have a ready outlet for their liquid milk. However, most farmers live a long way from major roads and have poor access to such markets, and these farmers have to rely on products which have greater storage stability than fresh milk.

Most of the milk produced by these isolated farmers is consumed by their families as fresh or coagulated milk. However, members of the Ethiopian Coptic Church abstain from milk and animal products for approximately 150 days per year. Hence there are periods when nearly all the milk produced must be converted into butter and cottage cheese, which have poor storage stability and are usually sold in markets nearby.

Since animals and their products contribute about 30% of the farm family's gross cash income (Gryseels and Anderson, 1984), improvements in milk processing could provide a substantial boost to agricultural development in the highlands. But before improvements can be made, it is essential that the traditional dairy technologies are understood in order to identify areas in which innovations can be effectively introduced. It is also important to define the way in which the existing technology fits into the farming system and the local community, lest a new technology should prove to be incompatible with current practices and the demands of the local market.

Fat recovery is an important factor determining the efficiency and profitability of smallholder dairy enterprises in the Ethiopian highlands. At present nearly 50% of traditional processors recover between 50 and 67% of the butterfat from whole milk, and a further 12.5% of producers recover less than 50%. The retail price for butter fluctuates between EB 10 and 23 per kg (US$ 5 and 11.5 per kg), depending on its quality and on market demand, which is high at Easter and during other feasts but low during the fasting periods prescribed by the Coptic Church. No premium is paid for any fat remaining in the main byproduct of butter making—the local cottage cheese called *ayib.* When the cheese is sold or, in the extreme case, wasted, poor fat recovery in butter can lead to considerable loss of income; however, when it is consumed at home, the fat remaining in *ayib* is a valuable addition to the diet, contributing in this way to the income of smallholders. A 10% increase in butterfat recovery could be expected to increase income by about EB 5 (US$ 2.5) per 100 litres of whole milk processed.

ILCA's dairy technology team has studied the traditional method of butter making to determine the efficiency of the process and the quality of butter produced. This paper summarises the results of the study and reports on initial experiments carried out to devise improved methods of butter making.

Dairying practices were monitored on 25 farms in seven locations in the Ethiopian highlands, and on 11 farms in the Debre Berhan area. Most of the farms were traditional smallholdings. Producers' cooperatives and farmers with crossbred cows who are collaborating in ILCA's research were also included. The enterprises surveyed were in locations ranging in altitude from 1700 to 3060 m a.s.l. Dairy production from crossbred (Boran × Friesian) as well as local Zebu cows was documented in the survey.

The quality of butter made and the type of equipment used were noted, and the quantities of milk processed were recorded. Churning by hand was studied in detail because it is not only the most important form of processing carried out, but also an activity in which there is likely to be scope for improvement. Parameters such as processing time, temperature., acidity and product yield were measured in order to gauge the efficiency of current churning practices.

Milk fat analysis of both the whole milk and buttermilk was done by the Gerber method on two samples of each (Foley et al, 1976). If a difference of more than 0.1% was observed, the analysis was repeated. Milk acidity was measured by titrating 10 ml of milk to a phenolpthalein end-point using N/9 sodium hydroxide. Churning time was the time interval between the start of churning and the visible formation of butter grains. Milk temperature was recorded using a thermometer.

Traditional butter making

Traditional Ethiopian butter *(kibe)* is always made from soured milk (*irgo*); cream is not used. The sour milk is placed in a clay churn or a bottle gourd (calabash). Churns are usually spherical, with a neck 10 cm in diameter at the narrowest point and a vent 0.5 cm in diameter near the neck. The churn may have previously been smoked with *Olea africana.* Besides imparting a distinct flavour to the butter, this practice has a bacteriostatic effect, and may reduce processing time by heating the churn. After filling, the churn is stoppered with a plug, a false banana leaf, or a piece of skin or leather stretched over the mouth and securely tied (Figure 1). The churn is then agitated. Four different methods of agitation were observed in the survey:

- The churn is placed on the floor, on a soft pad of material such as sheep skin or straw, tilted at an angle of 75° to the horizontal, and rocked back and forth (Figure; 2).
- The churn is hung on a tripod or door post and swung to and fro (Figure 3).
- The churn is rocked on the lap.
- The churn is shaken with both hands.

Figure 1. *Traditional earthenware churn. Background: Churn stoppered with a piece of skin.*

Figure 2. *Churning on the ground—the most common method observed.*

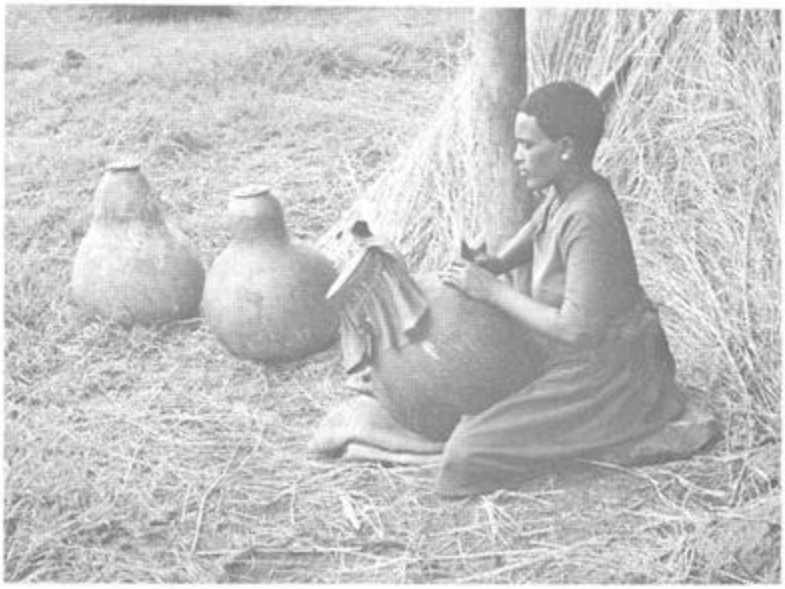


Figure 3. *Making butter in a bottle gourd hung from a tripod.*

The latter three methods are used only with bottle gourds, and only when fewer than 10 litres of milk are churned.

The break point, i.e. the point when butter starts to form, can be detected by a change in the sound of the milk. Many dairy women also insert a straw into the churn through the vent: if there are small butter grains adhering to the surface of the straw, the break point has been reached.

After churning for a few minutes more the straw is again inserted through the vent. If the straw is clean this indicates that the butter granules have coalesced into larger grains. The churn is then rotated on its base; the grains which collect in the centre form lumps of butter which are skimmed off. The butter is then kneaded in cold water and washed to remove visible residual buttermilk.

Butter quality

Butter is sold in rural markets and at the central, public butter market in Addis Ababa. The samples of fresh butter taken from these markets exhibited texture defects, particularly loose moisture, and a distinct smoky flavour. In rural markets the butter is sold by volume, the weight of which can vary considerably. In the Addis Ababa market butter is sold by weight. Samples of butter were analysed to determine the contents of moisture and free fatty acids (index of rancidity), and the serum pH (index of milk acidity). The serum pH of the samples ranged from 4.3 to 4.7, indicating that all the butter analysed was produced from sour milk. The moisture content varied from 2 to 43%, most samples having less than 16% moisture. The content of free fatty acids in the butter sold in rural markets varied from 0.23 to 1.20%. Older butter sold in the Addis Ababa market had free fatty acids content of as high as 23%.

For comparison, a study was also made of the quality of butter made on farms around Debre Zeit that use traditional methods and produce butter on a regular basis over a number of months. The moisture content of the butter varied between 13 and 30% and content of free fatty acids was between 0.07 and 3.32%. On some farms there was little variation in the composition of butter produced in different months.

Churning efficiency

The data presented in Table 1 reveal that churning time was long on most of the 25 farms studied, while milk acidity was high on nearly all of them. Churns were usually either over- or underfilled. In addition, commercial losses were considerable since much of the fat in the milk was not converted into butter—the product with the highest market value. The magnitude of these losses is indicated by the price differential between butter (average farm gate price of EB 9/kg or US$ 4.50/kg) and cottage cheese (EB 1/kg or US$ 0.50/kg). The butter produced also exhibited body defects in that it often had loose moisture and open texture.

Table 1. *Churning efficiencies observed on 25 farms in the Ethiopian highlands, 1983–1984*.

Farm	Quantity of milk (litres)	Acidity (%)	Fat in whole milk (%)	Milk temp. (°C)	Churning time (min.)	Fat in butter-milk (%)	Fat recovery[a] (%)
1	4	0.92	4.2	19	18	1.0	76
2	4	0.90	5.5	17	39	1.0	81
3	5	1.05	5.2	17	88	1.0	80
4	3	1.15	5.3	19	34	1.1	79
5	17	1.04	4.0	17	219	0.5	87
6	10	0.70	4.3	23	52	0.9	56
7	17	1.03	3.5	19	95	0.7	80

8	2	0.75	4.3	22	35	0.6	86
9	12	0.88	3.4	19	72	0.3	91
10	9	0.90	4.9	12	63	0.6	87
11	18	1.03	4.5	18	98	1.6	64
12	17	0.43	3.6	19	303	0.3	91
13	5	0.83	3.2	17	89	2.0	37
14	5	0.88	4.1	17	53	1.5	63
15	7	0.93	2.3	18	114	0.9	60
16	3	0.30	6.0	17	67	1.2	80
17	3	0.78	4.4	19	40	2.0	60
18	19	1.00	4.7	17	111	1.8	62
19	17	1.00	4.7	17	96	1.4	70
20	19	1.00	4.7	17	146	0.8	83
21	7	0.86	4.7	19	39	1.0	78
22	7	0.90	4.5	25	46	0.7	84
23	11	0.61	4.5	16	145	0.3	93
24	17	1.00	5.0	16	105	1.4	72
25	5	1.02	5.2	20	75	1.2	76
Average	10	0.88	4.4	18	90	1.0	75
SE	5.1	0.2	0.8	2.5	63	0.5	13

$$^{a}\text{Fat recovery} = \frac{\textit{fat in whole milk} - \textit{fat in buttermilk}}{\textit{fat in whole milk}} \times 100$$

Additional field observations were made to study the existing churning practices of members of the Bekelo Service Cooperative in the Debre Berhan area, who expressed interest in cooperative dairy processing. These data, which were collected during a baseline study of 11 farms, also indicate considerable losses of butterfat and long churning times (Table 2).

Table 2. *Churning efficiencies obtained with the traditional clay pot churn on 11 farms in the Debre Berhan area, 1984*.

Farm	Milk quantity (litres)	Milk acidity (%)	Fat in whole milk (%)	Milk temp. (°C)	Churning time (min.)	Fat in buttermilk (%)	Fat recovery (%)
1	7	0.73	4.2	13	150	1.0	76
2	6	0.95	5.0	15	170	2.1	58
3	11	0.89	6.5	16	150	0.6	90
4	9	0.72	3.9	18	120	0.7	82
5	7	0.79	6.0	19	150	1.6	70
6	4	0.80	4.5	18	60	0.8	82

7	13	0.74	4.1	19	105	2.0	51
8	3	0.80	3.8	18	150	0.7	82
9	11	1.15	5.5	20	55	0.6	89
10	7	0.84	4.8	15	105	0.5	90
11	10	1.10	5.1	13	270	1.2	76
Average	8	0.86	4.9	17	139	1.1	77
SE	3.1	0.15	0.87	2.45	58.6	0.57	12.8

Both surveys indicated that, in addition to being labour-intensive, traditional churning methods are inadequate to cope with a substantial increase in milk supply. Alternative methods to reduce churning time and increase the recovery of fat in churning were therefore investigated.

Performance of three types of churn

The performance of the clay pot churn was compared with those of a locally made and an imported wooden churn. The locally made churn is static, cylindrical, has a hand-operated revolving beater and a capacity of 30 litres. The imported wooden churn is also cylindrical but is fitted with fixed beaters and is rotated by hand. Its capacity is 31 litres. The traditional earthenware churn has a capacity of 24 litres, and the churning action is achieved by rocking the churn back and forth.

The milk used in the experiments was collected from crossbred Zebu x Friesian cows at the barn at ILCA headquarters. The milk was accumulated over a number of days and allowed to sour naturally before being bulked and mixed to ensure uniformity. Each churn was filled to half of its capacity with portions of the bulked, soured whole milk. The milk acidity was between 0.8 and 0.9% and the churning temperature ranged from 17 to 23°C. Churning time, fat content of the buttermilk and moisture of the final product were recorded using standard techniques (AOAC,1980). The churning time was the time taken to first formation of butter grains.

The trials were conducted with the three types of churn over a 3-month period in 1984. Table 3 summarises the results of these trials, presenting average figures for churning time (CT) and the fat content (FC) of the buttermilk.

Table 3. *Average churning time (CT, minutes) and fat content of buttermilk (FC, %) obtained with three types of churn, 10 replicates, 1984*.

	Local wooden churn		Imported wooden churn		Traditional clay churn	
	CT	FC	CT	FC	CT	FC
Range	45–64	0.5–1.4	35–55	0.5–1.2	96–224	0.5–1.4
Average	56	0.86	44	0.9	134	0.9
SE	6.51	0.36	7.76	0.25	43.1	0.296

The traditional clay pot churn is capable of churning whole milk as exhaustively as both the wooden churns, but the time taken for butter to form is considerably longer. Both wooden churns speeded up butter making and required less labour than the traditional earthenware churn, presumably because they had effective agitation systems. Unfortunately, they are too expensive for individual smallholders: even the locally made wooden churn costs about EB 200 (US$ 100), while the price of the imported one is around EB 500 (US$ 250). Moreover, as wooden churns are not normally produced commercially in Ethiopia, smallholders would have to use imported churns, which are difficult to obtain.

Improvements to the traditional technology

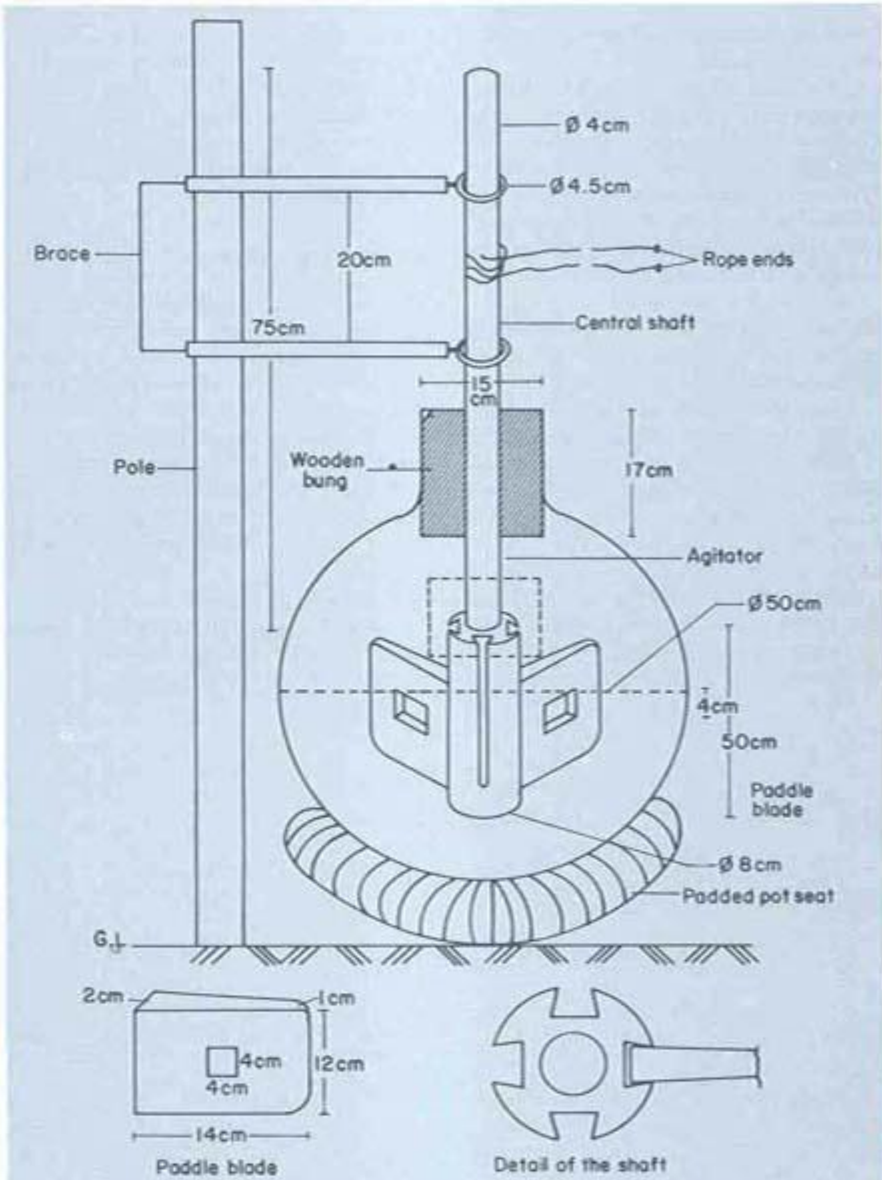
Two approaches could be used to improve the traditional technology. The first is to fit the traditional earthenware churn with an internal agitator. The second, which could be complementary to the first, would be to separate the cream from the whole milk before churning, thereby concentrating the fat in the cream fraction. This would give greater recovery of fat as butter, reduce labour input and increase the output from the churn. However, the small volumes of milk handled by most smallholders would make the use of a separator uneconomical. The performance of an earthenware churn fitted with an agitator churning sour whole milk was therefore investigated.

Internal agitation

The traditional churn has a minimum neck diameter of about 10 cm and an internal body diameter of up to 40 cm. The installation of an agitator in this churn presented a problem in that, when assembled, large paddle blades would not pass through the narrow neck, and paddle blades which were small enough to fit through the neck proved ineffective.

A simple, low-cost agitator that could be assembled inside the churn was designed and constructed by ILCA. It consists of a central shaft, paddle blades, and restraining shafts which fix the agitator in position. The paddle blades are fitted on the central shaft *in situ*. The agitator is driven by pulling on a rope wound around the main shaft of the agitator (Figure 4).

Figure 4. *Traditional earthenware churn fitted with a wooden agitator.*



Note: For smaller churns the dimensions of the paddle blades and shaft will have to be reduced proportionally.

In 1984 and 1985, 16 trials were performed at ILCA's Debre Berhan field station using locally purchased churns fitted with paddle blades made of soft wood. The milk for churning was collected from the station's crossbred cows and allowed to develop acidity naturally in a clay pot which was filled to half its volumetric capacity.

The data in Table 4 suggest that the simple internal agitation system can considerably reduce churning time, in addition to increasing the quantity of butterfat recovered. Studies are now being made on the effect of milk acidity, fat content, holding time and churning temperature on the exhaustiveness and duration of churning.

Table 4. *Churning efficiency of a traditional clay pot churn fitted with an internal agitator*[a].

	Milk acidity (%)	Milk temperature (°C)	Churning time (min.)	Fat content		
				whole milk (%)	Buttermilk (%)	Fat recovery (%)
Range	0.72–0.92	14–19	30–100	3.7–5.2	0.2–0.7	80–95
Average	0.83	16	61	4.3	0.4	90
SE	0.05	1.44	19.21	0.47	0.14	3.86

[a] Sixteen trials with a churn of 32 litres volumetric capacity; 16 litres of whole milk were used in each trial.

Cream separation

Full recovery of butterfat from whole milk is not possible, as the coalescence of fat globules is hindered by a large volume of intervening liquid (Hunziker, 1927). However, if cream is separated from the milk, a higher concentration of fat globules is obtained and, consequently, less fat is lost in the buttermilk. Cream can be separated from the milk by gravity or by centrifugation. These two basic methods are described below.

Gravitational separation is the process whereby milk is kept still in a cool place for a day or more and cream that has risen to the surface is skimmed off. Two techniques of gravitational separation can be used—shallow- and deep-setting separation.

The first technique uses shallow pans about 50 cm in diameter and 10 cm deep. Holding milk in these pans for 30 hours before skimming does not reduce the butterfat content of skim milk to less than 0.5–0.6% (Hunziker, 1927). Trials at the Debre Berhan dairy with locally available shallow pans gave comparable results.

With the deep-setting technique, milk (preferably fresh) is poured into cans approximately 30 cm in diameter and 70 cm deep and held for a period of 24 hours. This reduces the butterfat content of skim milk to 0.3–0.4%, and no further reductions can be obtained by holding the milk for longer periods (Jennes and Patton, 1959). The skim milk is drawn off through a tap at the base of the can.

Centrifugal separation involves simple but relatively costly machinery which gives excellent separation of cream, leaving only about 0.1% butterfat in the skim milk. However, the small quantities of milk (0.5 –4 litres/day) handled by the traditional Ethiopian producer make the use of the separator on individual farms uneconomic. A cooperative arrangement within a Dairy Producers' Cooperative, or among neighbouring farmers, would allow for more economic use of the machine.

A simple economic analysis of centrifugal separation, assuming a return to the primary producer of EB 9 (US$ 4.5) per kilogram of butter, suggests that the extra quantity of butterfat recovered through centrifugal separation over that obtained by gravitational separation would yield an additional EB 5.6 (US$ 2.8) per 100 kg of milk processed. Assuming that the cost of a centrifugal cream separator is EB 1000 (US$ 500), and the interest on the loan plus maintenance costs over 5 years is EB 230 per year (US$ 115), then the break-even point is 230/0.056, or 4107 litres of milk per year. This is approximately 12 litres/day, so for a single large producer, or a group of farmers, the technique could be economically viable.

Conclusions

The modified earthenware churn has considerable advantages over the traditional churn. The innovation is simple, cheap and effective: the trials reported in this paper indicate that as much as 90% of the fat can be recovered from whole sour milk with considerably shorter churning time and with less labour input than with traditional methods. The improved technology could thus lead to useful increases in the incomes of smallholders.

Gravitational separation of cream also increases fat recovery and reduces churning times. However, the volumes of milk handled daily on the typical highland farm are so small (0.5–4 litres) that no appreciable benefits could be gained by introducing this method. The combined fat losses in the skim milk and the residual buttermilk would probably be just as high (about 10%) as the fat losses in the buttermilk remaining after churning whole milk. Centrifugal cream separation would be economically justifiable only if larger volumes of milk (over 12 litres/day) were available for processing.

Trials to test cream churning demonstrated that the improved earthenware churn is capable of churning cream exhaustively in about 60 minutes. Combining centrifugal separation with the improved churn should ensure profitable processing of quantities of milk of the order of 100 litres/day. Larger volumes of milk would require a wooden churn in addition to cream separation.

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