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MILK PRESERVATION, PROCESSING AND DISTRIBUTION IN DEVELOPING COUNTRIES[1/]

by

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1. [illegible]

By making general surveys on the milk production of a developing country, wrong conclusions on the demand and the consumption of milk can easily be made. On the one side we know that, for special reasons, in West African babies suckle up to two years, but on the other side there are taboos for adults to drink milk. In Iran babies are even nursed up to four years, although it is known (1, p.[illegible]) that the market for milk is not of special importance in this region of the world. Therefore it is wrong to conclude immediately that there is a shortage of milk in these countries. These two examples demonstrate, however, how difficult it is to draw general conclusions about a developing country's milk market, milk consumption and milk production. The danger of a one-sided point of view really exists. Nevertheless an increase of milk production in these countries is enforced and consequently supported. If one, on the other side, considers the problems which are connected with milk production and milk processing in warm developing countries, one has to ask the original question: why stimulate demand for milk and consequently increase milk consumption? On the one side you can find statements that per annum [illegible] people starve to death because of animal protein deficiency [illegible] and that this especially goes upon people living in the so-called west nile-belt. In a staggering report from a symposium in Brazil it has been stated that the per centage of babies dying during the first year is [illegible] per cent and [illegible] per cent for those dying before the age of five years (3, p.51). Similar reports from different developing countries are known. On the other side there are developing countries with little foreign currency like [illegible] and, which spends [illegible] per cent of its foreign currency for food imports like milk and milk products (4, p.[illegible]), or they get around the nutritional-physiological problems by substitution products like 'Soja-field Vitamilk' (4, p.12). The technical problems that are connected with a build-up of milk production, including the fact that milk is easily spoiled in such a region, above all seem to indicate that other possibilities should be found, i.e. importing milk powder surpluses from Europe, the United States of America or Oceanic Islands (5, p.[illegible]) or imitating milk products as is done in

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2/ Numbers in brackets refer to references listed at the end of this paper.

Thailand, Bulgaria and Hong Kong. Nevertheless strong efforts are made all over the world, to encourage milk production decisively, as can be seen from an FAO figure (Figure 1), because on the one side there is no doubt about the

Figure 1. Dairy Projects in the World Supported by FAO and Similar Organizations (1).

nutritional and physiological value of milk, especially for the child and the baby, and on the other side there is the fact that milk easily can be digested, especially by young children. In addition the expression "milk" includes other values for many people who take a positive view towards an increase in milk production. Furthermore milk cannot be considered without thinking of all the other milk products, either that milk is transferred into a more suitable form in the tropics, e.g. fermented milk for adult nutrition, or that by-products have a special significance for people in developing countries, e.g. buttermilk in India or Thailand. Without encroaching on the nutritional judgement, these products can be considered as very valuable for adult nutrition because of their protein content from Zebu and water-buffalo the milk of which is able to substitute the protein content of normal milk.

Table 1. Protein Content of Milk, Fermented Milk and Buttermilk in Tropic Countries (7).

Kind of Product	Protein Content*) (%)
Cow's Milk	3.3
Sheep's Milk	5.3
Goat's Milk	3.7
Buffalo's Milk	4.1
Camel's Milk	3.5
Zebu's Milk	3.8
Buttermilk	3.5
Joghurt	4.8
Kefir	3.0

*) Mean-values; in many a region there might be higher results.

If, according to the nutritionist, one quarter of one litre milk (250 cm^3) per day is enough to fill the need for animal protein and to eliminate the worst damage, even buttermilk is good enough for this purpose.

2. Milk as a Cause of Different Diseases

If one comes to the conclusion that milk production in developing tropic countries should be supported because of many reasons, one also has to support the consequences resulting from the medical and veterinary point of view. Otherwise, if milk products are not under regular control in a developing country, milk is a source of danger, which stands against the nutritional value. In this sense table 1 should be understood.

Therefore it is not possible to give full information on the preservation, processing and distribution of milk in developing countries without mentioning these medical and veterinary requirements. It can be easily understood that people do not want to drink milk because they are afraid of infection (9, p.6).

Table 2. Diseases Transmissible to Man through Milk*)

Causes of milk-borne diseases	Disease
Bacterial infections	Anthrax Brucellosis Bacillary dysentery Leptospirosis Listeriosis Paratyphoid fever Salmonellosis
by streptococci	Uncertain Tuberculosis
by coli infections	Uncertain
Viral and rickettsial infections	Foot-and-mouth disease Tick-born encephalitis Q fever
Protozoal infections	Toxoplasmosis
Intoxications of bacterial origin	Staphylococcal enterotoxin food poisoning
Heavy contamination with certain bacteria	Uncertain
by B. cereus	
Uncertain etiology	
by escherichia, proteus	Uncertain
Pseudomonas etc.	

*) After M. M. KAPLAN, M. ABSUSSALAM and G. BIJLENGA: Milk Hygiene. Hygiene in Milk Production, Processing and Distribution. World Health Organization Monograph Series No. 48. Geneva 1962. (8)

3. Medical and Veterinary Requirements

Because of the relationship between the hygienic quality of milk and its keeping quality, first of all one has to ask for a very primitive hygiene, that is to say changing habits which are intolerable for milk hygiene. For instance straw is used against spilling of milk in buckets (10, p.43) or oil cans are used for milk transport and milk measurement (6, p.34). Therefore one has to ask that cans are provided for the transport of milk (1, p.46). At the same time flies and chickens in the cow barns should be eliminated. Milking hygiene is also unknown in most of the developing countries (9, p.22). Especially the use of the water buffalo in the country for milk production is accompanied by problems if we consider that these animals have to run through dirty water pools

once or twice per day. In order to change the worst, each milk producer's farm should be checked by a veterinarian before he is allowed to ship milk - maybe this is a successful way, as it is done in Iran (9, p.[illegible]).

In addition the veterinary control is an inevitable condition for the struggle against the tsetse because of trypanosoma-diseases and for the reduction of ticks (11, p.14), which helps the meat production in developing countries. The costs for such a campaign in those regions are considerable. In Nigeria the costs for tsetse-campaign were [illegible] per km^2 (12, p.[illegible]). The build-up of small scientific research stations for animal hygiene can be observed everywhere in the developing countries; those stations have, at the same time, to control the terrible epidemic diseases like rinderpest and pleuro-pneumonia (12, p.20). As a result of this improvement more fertile areas can be used as pasture for animals. By this way, the unbalance of animals in several countries could be equalized. For instance we find 90 per cent of the animals in the less fertile provinces of Northern Nigeria, whereas in the southern provinces where the tsetse in widely spread we have the remaining 10 per cent (12, p.25). Even if there are no regions in the world, not even in the desert, where a farm could be established (13, p.2), one should prefer those regions in a country that are suitable for animal production because of their natural conditions. In addition, economic aspects over a long time period should be considered in developing countries. Unfortunately it is only possible under high costs and very intensive arrangements to make the fertile regions usable like the Guinea-zone of West Africa. At the same time, however, a lot of effort is spent for general human hygiene.

II Milk Preservation

In developing countries many approaches for milk production already exist. One can think not only of the many existing zebus and water buffaloes, which represent more than 60 per cent of the cattle stock mentioned above, but also of other milk-producing animals like goats, sheep and camels. However, milk production in developing countries has the disadvantage that very often only the daily requirement is considered; therefore all steps taken towards a continuous production become doubtful because of their dispersion and extreme decentralization. It does not seem useful to me to talk about milk preservation if I think of already existing large plants like in Tehran (Iran) or Bombay (India)

because this would mean to transfer European or United States standards to developing countries. This, however, would lead to wrong conclusions and even to false arrangements. As far as I'm concerned above all small units for milk production should be established. In this stage of development the problems of preservation, processing and distribution of milk and milk products have to be considered differently as compared to larger units.

[illegible]. Conditions for Milk Production

If we want to supply a developing country's population with milk we have to supply milk throughout the year. Dairy plants in developing countries which do not operate year round - like the plant in Vom, North Nigeria only 8 months - stand against this principle. Therefore steps have to be taken to make milk production possible throughout the year. This is mainly a question of feed production rather than breeding. If one reads, however, the reports of different research stations in developing countries, one always can find results on the cross breeding with European cattle in spite of the well known disappointments with the minor ability of European cattle to adjust under tropical conditions and in spite of the marked decrease in milk production during the second lactation. Therefore all measurements have to be taken towards the number one problem: effective feed production. While taking many factors into consideration one comes to the conclusion that an increase in milk production is only possible if enough feed is provided (table 3).

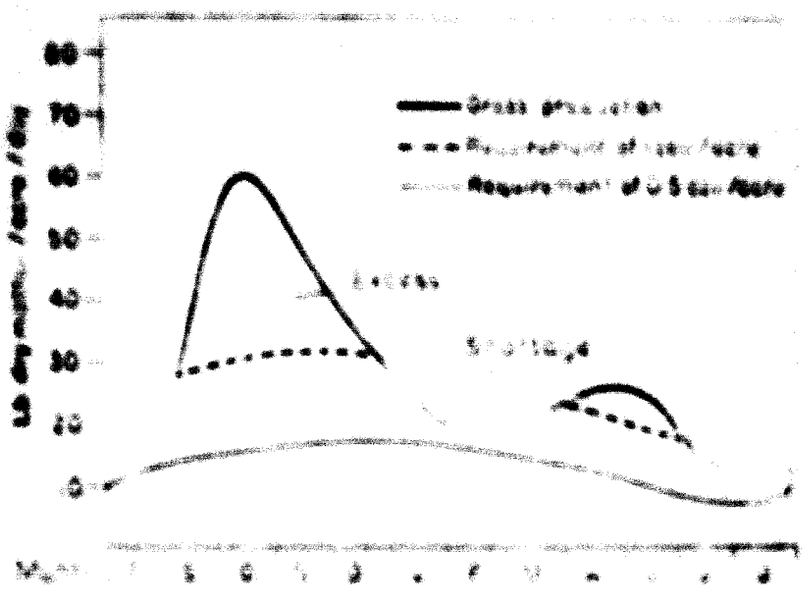
Table 3. Percentage of Increase in Milk Production by Different Factors (14, p.10).

Factor	Percent of Milk Production (%)
Feed	40 - 45
Fertility	20 - 25
Animal Health	10 - 15
Genetical Factors	10 - 15

From table 3 it can be seen that in the first stage of development feed supply and animal health are much more important than breeding. For many developing countries pasture farming and feed production are completely unknown (1, p.9). The lack of feed reserves not only causes the loss of cattle as in Syria (15, p.40) but also leads to a decrease in milk production. Arrangements for fodder

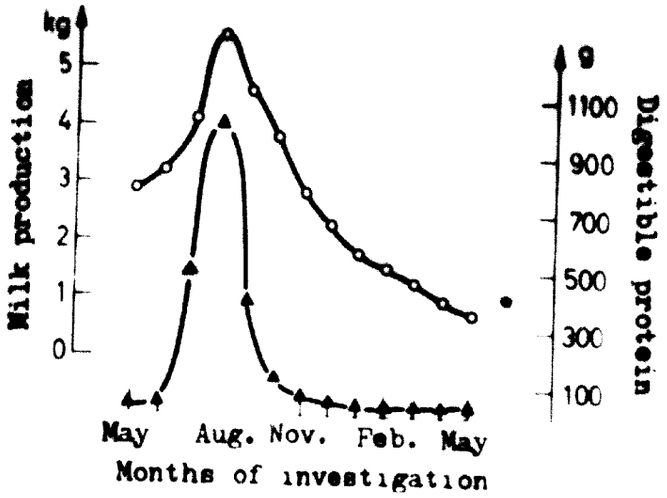
production, pasture farming (1, p.9) and feed preservation have to be absolutely co-ordinated with milk production. The seasonal feed surplus (16, p.129) has to be correlated with the supply of dairy cattle as well as with human nutrition itself. The immense feed surpluses after the rainy season, allowing double cropping, have to be preserved (see figure 2).

Figure 2. Relationship between Grass Production and Dairy Cow Requirements (Based on data supplied by J. B. Hutton and N.S.R.M.St) (16, p.129).



By the improvement of feed supply the wandering of cattle, which very often causes deficiency in feed supply for the dairy cattle because of the long distances, is restricted [illegible] or has become even needless. Nomadism is caused by the force for feed equalization (1, p.11). Also the problem with Bedouins is solved by feed supply (1, p.20). According to our investigations, dairy cattle in the subtropical zone, which stands for more than 15 per cent of the world's surface, live with protein deficiency for 8 - 11 months; during this period we find a sharp decrease of milk production (figure 1) and an insufficient fertility - the cows only get calves in a two to four year period.

Figure 3. Relationship between Milk Production and Digestible Protein in Feed (Rainy Season).

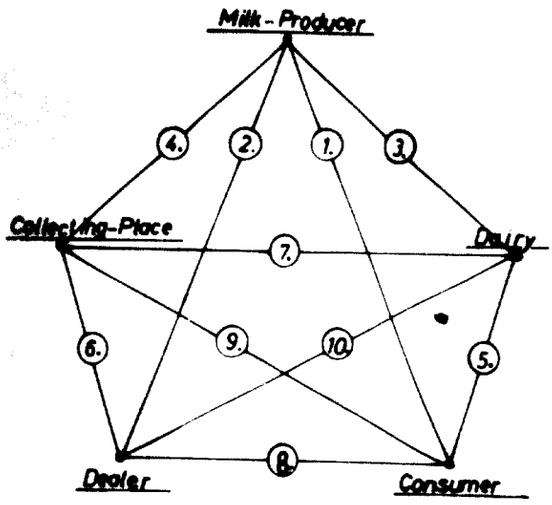


As soon as silage is provided for the cattle, a three and fourfold milk production is possible (18). Whether the example of Israel, where very high milk production is enforced by imports of concentrates (19, p.783) can be accepted in general has to be decided for every developing country separately (9, p.21).

2. Milk Collection

Milk collection and milk preservation are directly connected. As can be seen from the way of milk from the producer to the consumer in figure 4, there are many possibilities how in a developing country the milk finally reaches the consumer; accordingly varies the milk treatment too.

Figure 4. Way of Milk from Producer to Consumer. (Compare the different names in the text).



a) Outlet of Untreated Milk

The direct way of milk from the producer to the consumer (way no.1) is mostly still used today in developing countries. In Tehran an estimated 50 - 60 per cent of the milk is shipped directly from the farmer to the consumer in the city (20, p.49) thus not going through the state-dairy; there are, depending on the season of the year, between 45 - 70,000 litres of milk per day. From other countries similar reports are known (4, p.12); in extreme cases - as it is reported from India (21) - the farmer takes the cow into the city and milks the desired amount of milk while the consumer is waiting for it ("Dairy on Six Legs").

Raw milk also might be passed to the consumer by the dealer (way no.2/8), whereby milk producers might be dealers at the same time, if they take the neighbour's milk to the market and sell it (as in Iran). From a long-range point of view, one cannot tolerate these for hygienic reasons very dangerous

possibilities (way no.1 and 2/8), but one should try to establish collecting places to stop the selling of raw milk (way no.4). It depends on the local conditions whether the collection place is treating the milk and shipping directly to the consumer (way no.9), maybe through the dealer (way no.6/8) or whether milk is only collected for shipping in larger cans or tanks to the dairy (way no.7). Larger amounts of milk should not hinder the transport of milk from one collection place to a creamery even over long distances. In tropic Australia raw milk is transported in deep-cooled tanks up to 345 kilometres without influencing the keeping quality (22, p.2). The good keeping quality of deep-cooled milk even inspired experts to propose that under direct shipment to the consumer pasteurization would not be necessary if a special time interval is observed. According to this proposal milk should be cooled at least one hour after milking and shipped to the edge of the city in 40-litre cans in 2½ hours where milk should be sold within a special limited time (14, p.24/25). This would mean that raw milk could also reach the consumer via the collecting place (way no.4/9 and 4/6/8). The expert reasons that the consumer in these developing countries, afraid of the raw milk's danger, cooks the milk anyway. I'm very critical on this point of view because of the possible dangers in transmission of diseases in developing countries, as has been demonstrated in table 2.

b) Outlet of Chemically Treated Milk

The different ways of distribution of raw milk therefore can by no means be supported. There are also immense objections against the chemical preservation of milk with H_2O_2. Using H_2O_2 for preservation the FAO standard requirements read as follows:

> "Of the range of preservatives available at present, the only one that is permissible for milk that is to be used for human consumption or to be manufactured into milk products is a pure grade of hydrogen peroxide (sold commercially in aqueous solution of differing strengths).
>
> The addition of hydrogen peroxide should be made at the milk collecting centre, and should not be made by the milk producer unless in exceptional circumstances the sanitary or other competent authority so decides.
>
> If, owing to difficult local conditions, permission is given for hydrogen peroxide to be used, either by the producer or by the collector of milk, the quantity to be used should in no circumstances exceed 0.80 g of H_2O_2 (calculated as pure H_2O_2) per litre of milk, and should usually, for milk for liquid consumption, be between 0.10 g and 0.40 g H_2O_2 per litre.

Since the function of hydrogen peroxide is merely to delay the souring of the milk, and since this preservative at any permissible strength does not destroy certain types of pathogenic micro-organisms (including M. tuberculosis), any milk treated by hydrogen peroxide must subsequently be subjected to effective heat treatment before being distributed to the consumer or during the course of manufacture.

Whether hydrogen peroxide is added to milk destined for liquid consumption or for manufacture, such additions must be very carefully controlled, and official tests made sufficiently frequently to ensure that the preservative has been destroyed before the milk and milk products are distributed to the consumer.

If catalse is added to hydrogen-peroxide-treated milk to destroy residual preservative, the enzyme preparation must be entirely satisfactory from the enzymic, chemical and bacteriological standpoints.

As the addition of hydrogen peroxide to milk is known to affect to some extent the quality of the milk, further investigations are recommended to evaluate more precisely these changes in relation to human health and nutrition (vide the report of the Joint FAO WHO Expert Committee on Food Additives .....(World Health Organization 1957)).

Finally, it must clearly be recognized, both by the controlling authorities and the technical personnel concerned, that the use of hydrogen peroxide is not a hygienic measure, and is no substitute for efficient heat treatment. In short, it is a method which, in other than exceptional circumstances, is not to be recommended."

Although the biological value, especially the one of protein, is hardly altered in milk by the use of H_2O_2, no more than the chemical composition and the nutritional value - only vitamin C is lost - objections exist whether the hygienic dangers in milk are really removed by the use of H_2O_2. One should not be imposed on by the fact that H_2O_2 applied at the dose 0.8 g/l has a killing effect between 99.8 and 93.6 per cent depending on the temperature so that there is in part an even higher bacteria reduction than during pasteurization; however, a lot of pathogenic micro-organisms certainly survive H_2O_2 treatment. So does mycobacterium tuberculosis survive 0.08 per cent H_2O_2 solution. There is no agreement in the literature on the killing of brucellae; therefore experts for milk hygiene have emphasized that the epidemic danger is not banished by the distribution of H_2O_2 treated milk.

Therefore milk can reach the consumer via the collecting place in the raw, only chemically preserved form, as it is reported to be, according to FAO figures, in collecting places on Madagascar (10, 33). In special cases according to experts this should be allowed for milk producers too (FAO resolution, article 3). It is unclear in this resolution whether this possibility (way no.1 is also provided for the direct shipment of milk from the producer to

the consumer. If this possibility is seriously taken into consideration, then shipping of chemically preserved milk only should be allowed through the collecting place (way no.4/9).

c) Pasteurized Milk

The pasteurization of milk is, above all, the best method for the developing countries too, because the possible transfer of diseases through milk enforces the heat preservation especially in the interest of the country's population. Pasteurization of milk, however, requires the build-up of a cooling chain, whereby it does not matter whether the collecting place or whether the dairy is responsible for it. That pasteurized milk can well be transported over long distances shows the example of the collecting place Anand, India, where pasteurized milk is shipped in isolated tanks over more than 415 km to Bombay. The possible ways to a collecting place - milk consumer (way no.6/8) and dairy - consumer (way no.5 and 10/8) therefore should be spared mainly for pasteurized milk.

Because of the hygienic conditions in developing countries, very often the question has been raised again and again whether the generally used pasteurization time and temperature (71 - 74°C for 15 to 45 sec) or the high temperature pasteurization (85°C) are enough, to provide the consumer in a developing country with a milk of high keeping quality. The thorough investigations of AUCLAIR (23) clearly indicate that milk from tropic countries has a lower bacterial count than milk from French milk producers (table 4).

Table 4. Bacterial Counts in Milk from Tropic Countries and from France
(Calculated as Arithmetic Mean Value from Data Supplied by AUCLAIR (23))

Origin of Samples	Number	Bacterial Count (1 Mill/ml) Mean Value ± Standard Deviation
Tropic Countries		
Central African Republic	38	0.36 ± 0.32
Chad	80	1.63 ± 5.39
Senegal	6	0.003 ± 0.003
India (Cow)	13	2.13 ± 5.36
India (Buffalo)	40	16.96 ± 86.0
Mean Value (Cow)	135	1.25 ± 0.38*)
(Buffalo)	40	16.96 ± 13.6*)
France		
Farm E	68	47.58 ± 87.77
Farm A	35	3.30 ± 7.00
Farm M	18	4.20 ± 7.00
Herd J	43	0.013 ± 0.012
Mean Value (Cows)	161	20.95 ± 4.80*)

*) Error of the mean values. The difference in mean values of bacterial count in cow's milk from tropic countries and from France is significant (p 0.01).

AUCLAIR does not see any special inhibitory substance in tropical milk as causing agent but rather states that by the absence of milking machines and by the fast drying of the equipment in contact with milk, there are no secondary infections and therefore lower bacterial counts in general. Thereby the keeping quality of raw milk is relatively long and for most of the milk samples from tropic cows from 10 - 15 hours at 37 - 42°. Special conditions can be given by the presence of special micro-organisms; A. LAI (24, p.20) observed coagulation by micrococci without acidification. Special climatic conditions also can cause a higher rate of losses. In India, for instance, a higher percentage of sour milk has been generally observed during the monsoon season.

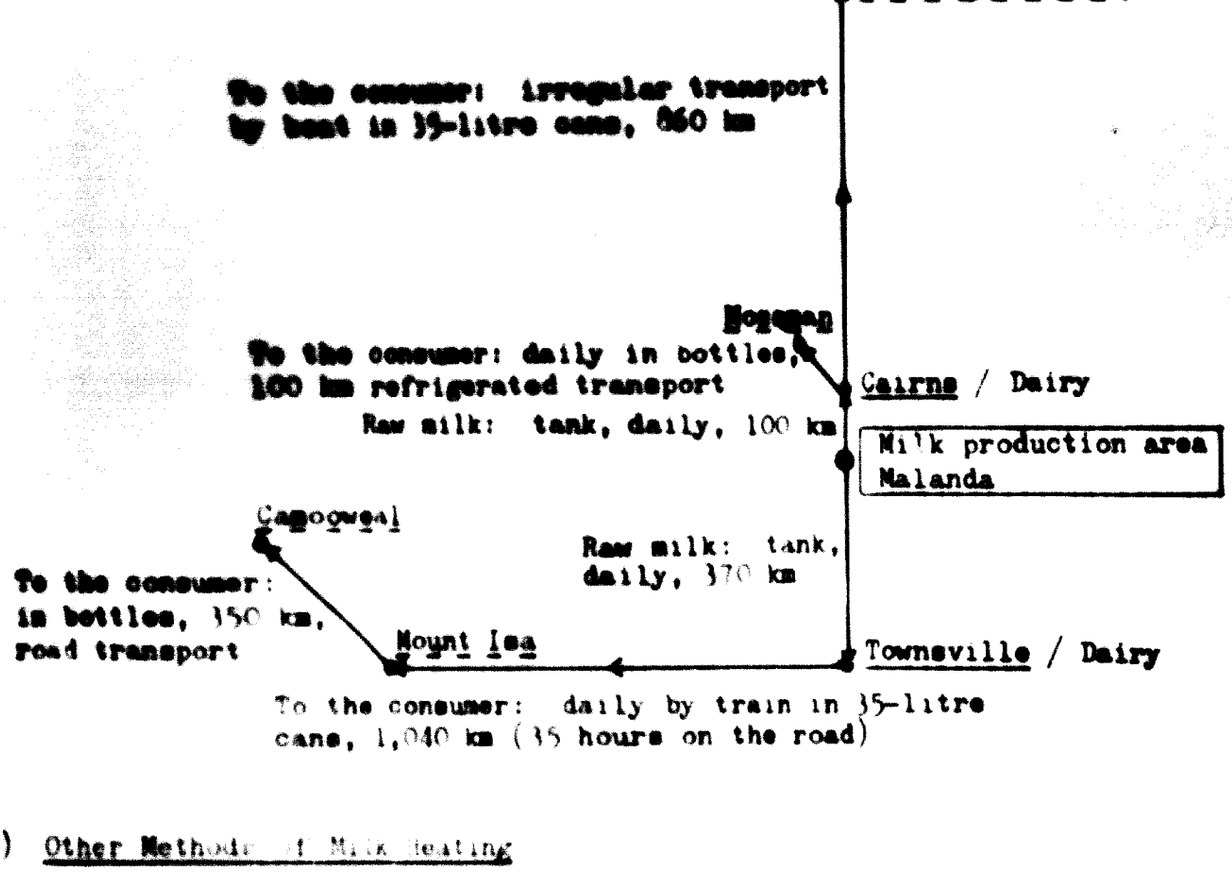
Whether high temperature-short time or high-temperature pasteurization should be recommended for developing countries also depends on the taste of the population. If only cooked milk was used, at least for the first time high-temperature pasteurized milk should be offered to the consumer.

d) Cooling of Milk

With pasteurization of milk its cooling is very closely connected or, expressed in other terms, pasteurized milk requires the build-up of a cooling chain from the collecting place to the consumer (way no.9 and 6/7) respectively from the dairy to the consumer (way no.5 and 10/11). In general, temperatures of less than 10° C - the lower the better - are recommended for cooling of pasteurized milk. However, one has to take into consideration that cooling devices are very expensive (24, p.4). In Delhi 3°C, in Kenya 4.5°C is applied; in cold-walled milk storage tanks, even 1°C is used. These low temperatures guarantee a high safety for the transport of pasteurized milk over large distances, as from Anand to Bombay (see above) and as with the transport from Townsville to Mt. Isa over more than 970 km in Australia (figure 3).

In several countries it is even required that the farmer pre-cool the milk before shipping to the creamery. So does the dairy in Tehran only accept milk if the temperature of 15°C is not exceeded (20, p.39). To fulfil this requirement during the hot season of the year is not very easy. This might be the reason why a large amount of milk goes directly to the consumer, as is done by the farmers in Tehran.

Figure 5. Possibilities of Milk Transport over Large Distances with Good Co[illegible] under Unfavourable Conditions (21, p.945).



e) Other Methods of Milk Heating

The combination of milk pasteurization and cooling in developing countries under tropical conditions without any doubt represents a handicap, which causes high costs for investment and maintenance. Sterilization of milk as a basis for a population's milk supply has always been rejected so far, because these products are said to be of minor biological value. Intense scientific investigations, however, as well as the application in infant nutrition on a large basis in Israel over many years before the establishment of a dairy industry, have shown that these opinions are untenable. Sterilization with a simple autoclay at [illegible] offers the possibility, besides saving the money for a cooling chain, to work with relatively small units so that for the build-up of a dairy industry in a developing country, first of all only small dairies and collecting places are necessary. Each increase

in milk shipment can be equalized by changing the time of operation and by instalment of a second unit. For these reasons one believes that for small amounts of milk sterilization is more economical than pasteurization, since there is no cooling chain and lower costs for processing (26, p.20). Therefore many experts favour sterilization arguing that there are many advantages such as no cooling chain (24, p.4) and large distribution of milk over huge areas usually not reachable (27).

> "It must be a big market for sterilised milk in developing countries, because there were families who lived in areas without daily supply of ice and no electrical refrigerators" (26, p.16).

As another modern method we today know the ultra-high-temperature treatment, whereby milk is completely freed of bacteria and stands very close to pasteurized milk in its taste. The marvellous experiences with this milk during week-ends and vacations in European cities favour recommendation of this new type for milk preservation whereby it does not matter whether the direct or indirect method is selected. Larger amounts of milk, however, have to be available for this method. Such a plant already exists in Abidjan, Ivory Coast.

f) Other Types of Preservation

For adult, but not for baby and infant nutrition, we have to consider the different fermented milk products as a source of animal protein. In part these products still have a greater importance today than fresh milk, for instance yoghurt in Iran (20, p.7). In India, the Middle East and Manila acidified milk also plays an important role as do kefir and yoghurt (18, p.39). Since acidified milk correspond partly more with the people's taste, probably because they are used to it, an increase of milk consumption could be obtained in this way. In addition, the use of fermented milk has the advantage that further amounts of milk which cannot be sold because of unfavourable traffic conditions, are available for nutrition. Here again, we have a good example looking at the milk supply in Tehran. Milk which does not fill the requirements of the dairy for temperature and acidity is sold directly from the producer to the consumer as a fermented milk product (way no.1).

Although milk consumption can be increased by this possibility, objections have to be mentioned because we have the same conditions as with raw milk if we think of hygiene. Investigations on the influence of souring on

different pathogenic bacteria in tropic milk are not available, but there are comparable results available in the literature which allow analogical conclusions (table 5).

Table 5. Viability of Pathogenic Micro-organisms in Fermented Milk Products (SCHÖNBERG (28) and HÖKL (29)).

Milk Product	Viability of Brucella-Bacteria in Days	Foot-and-Mouth Virus in Days	Tubercle Bacillus in Days	Typhoid Germs in Days
Sour milk (20°C)	3 - 4	5*)	18 - 21	5
Buttermilk (4-5°C)	9 - 35		11	
Quarg	24		14	
Kefir	11		14	5
Yoghurt	8		14	3

*) According to other data no viability.

Therefore the use of raw, but fermented milk for production of yoghurt and kefir is as objectionable as the use of raw milk itself; therefore it cannot be recommended. If, however, a possibility for heating exists at a collecting place even if this is a very primitive one, the preservation of milk by fermented cultures would be approved (way no.9 and 6/8).

III Processing of Fluid Milk

It is my intention to desist from more than characterising the well known forms and phases of fluid milk processing; I rather want to describe the conditions for milk marketing in developing countries.

1. Size of Dairy Plant

The tricky question, how large a dairy plant should be built, must be answered realistically. Everywhere there are statements that dairies built in developing countries are too large (14, p.25) so that over a long period of time economic disadvantages go along with it (30, p.20). The minimum capacity should be at least 5 - 10,000 kg of milk per day. Israel gave a good example for the build-up of a dairy plant in Jotfata, which is located in a very dry region; first the plant was projected to process 5,000 litres (31, p.52) and was later, after a few years of development, adjusted to the increasing demand.

Aspects of technology and economy should be preferred to those of prestige thinking (32, p.37a). If the proposed minimum amounts cannot be achieved, then one should be satisfied with collecting places equipped for centrifugalization, pasteurization and cooling. Collecting places very often prove to be better than large creameries, because they work more effectively with smaller amounts of milk (9, p.41) and because they are privileged for further development (), p.57). The native experts also can handle the smaller processing units much more easily than they can the large ones.

Calculating the amount of shipped milk in a district, the following aspects should be considered:

1. Number of dairy cattle, the milk of which can be brought to the collecting place and the dairy within an hour on foot (way no.4 and way no.3).
2. The daily milk yield per cow should not be calculated higher than 1 - 2 litres. Exact figures have to be obtained by test milkings.
3. From this amount of milk 25 - 40 per cent has to be deducted for use on the farm (14, p.19; 20, p.6).
4. Shipping milk from the collecting place to the dairy (way no.7), the road conditions, especially their usability during rainy seasons, have to be taken into consideration.

With the knowledge of these factors the amount of milk to be expected can somehow be calculated. After this a decision is possible as to how much fluid milk can be processed, what type of heat treatment should be used and what kind of other products can be included in the production programme. In general, one also might consider the production of ghee.

2. Collecting and Receiving of Milk

Because of the road conditions, which in general do not allow collecting close to the producer, the shipment to a collecting place must be required; in very unsuitable cases perhaps a pre-collecting place should be installed. For lack of usable cans these must be prescribed in material and size or they have to be provided uniformly as is generally done in dairy countries.

Only if larger amounts of milk are shipped as in the so-called "milk colonies", the transport from the collecting place to the dairy by tanks is feasible. In developing countries, a parallel shipment of milk by tanks as well as by cans to a dairy cannot be avoided, as in Delhi (25, p.12).

The control of milk is, even if this might sound very strange, an extremely important measurement in processing fluid milk. In developing countries the percentage of altered milk is unthinkably high so that no milk can effectively be received without checking for water alteration. Here too one should be moderate in establishing places for milk testing. As a basis for installing a laboratory in the first phase of a dairy build-up in a de eloping country, the test for water alteration (aerometer), for fat (butyrometer), for dirt (filter method) and at best the reductase test should be enough. If instructions for milk cooling are possible because of the water conditions, the observance of these instructions of course have to be controlled by temperature measurements.

The instalment of cooling devices depends largely on the local conditions. In Northern Nigeria cooling in cans would be possible in several districts because the temperature of spring water is about 12°C. In general, however, one will need the usual cooling devices to keep the milk in storage tanks at 4°C. Closed cooling systems can be recommended because of thunderstorms lasting for weeks, especially during the dry season, thus polluting milk because of the free surface of milk in surface cooling devices. Therefore, even in small plants surface cooling systems should be avoided.

In most cases, clarification of milk is included before pasteurization or any other type of processing. Here too one should consider the small unit the most simple method, namely filtration by cloth or filters. If centrifugalization is somehow possible, clarification should be applied too, because long lasting floods as in West Africa and in the highlands of Iran, can cause a very strong and sandy sedimentation in milk.

3. Heating of Milk

For pasteurization of milk, modern plate pasteurizers are used which combine heat exchanger, heater, water and brine cooler. The high-temperature (85°C) as well as the high-temperature short-time pasteurizer (71 - 74°C for 15 - 45 sec) operate continuously so that 1,000 - 10,000 litres of milk per hour generally can be heated. These heating devices require a high technical standard in the developing country so that they can only be recommended for collecting places or dairies that are located in cities with sufficient water and electricity supply.

Under primitive conditions one also could think of a jacketed vat for 500 litres heated by steam or hot water. The temperature should hold at 65°C but not lower than 60°C for about 30 minutes. This heat treatment corresponds with holder pasteurization which in its modern modification is still allowed in many countries by law. The disadvantage of this discontinuous processing can be equalized by combining several vats into one unit so that by filling these vats in special intervals a somehow continuous filling of the bottles is possible. This holder pasteurization is not directly possible as in-bottle pasteurization.

The ultra-high short-time temperature pasteurization generally might come into question only for dairies in cities with large amounts of milk to be processed. However, for economical reasons, such a device also might be interesting for smaller plants. The smallest device allows the processing of about 500 - 1,000 litres of milk per hour. These modern units, however, should only be taken into consideration if a germ-free filling in disposable containers goes along with it. The indirect ultra-high short-time pasteurization operates as plate or tubular heater at 135 - 140°C, whereas the direct method operates with steam injection into milk at 150°C and a hilding time of 2.4 seconds.

4. H_2O_2 Treatment

As can be seen from the already mentioned standards (page 12) for the special application, exact working instructions have to be given, whereby special care has to be taken because of the constant decrease of the concentration of H_2O_2 in open storage cans. A continuous control of the milk before and after storage for H_2O_2 is absolutely necessary.

5. Milk Packaging

Only under special distribution systems as in India can one desist from packaging, but otherwise one absolutely has to favour packaging of milk because of dangers like impurification, reinfection and alteration. The deficiency of milk in developing countries has contributed a lot to the fact that market milk is altered in an unimaginable way, as it is reported by the milk and marketing board in Lahore where 97.3 per cent of market milk was altered (33, p.8).

In general the glass bottle is used as package. There are difficulties, however, if they first have to be imported because there is hardly any glass industry in the developing countries or there are long distances between the glass factory and the dairy as in India (34, p.3). Therefore the disposable package should, if at all possible, come into use (35, p.10), because the transport, cleaning and disinfection of bottles and especially the bottle washing machine can be spared; furthermore the detergents, the disinfectant solutions and the water, which makes twice as much as milk, are not necessary. As strange as it may sound, for the developing countries the use of plastics seems to be not only the most suitable from the technical point of view but also the most economical way of milk packaging. Thinking of the good experiences he made in Israel, ROSENFELD favours the polyethylene package. He verbally states:

> "It seems that packing fluid milk and fluid milk products as Mokto-milk and Moka-milk and so called school-milk can be a very cheap solution for the distribution of milk in developing countries" (31, p.52).

Considering the intensive sunlight radiation, however, only polyethylene packages with light-protecting film should be used.

6. Specialities of Milk Processing

In general the high fat percentage makes it necessary to standardize, as is commonly done all over the world. The essential and nutritional part of the milk, the protein, is not influenced by this technological step; we always have to keep in mind that milk production in developing countries is enforced because of their deficiency in animal protein. The economic profit, which results from cream separation and the following production of ghee, helps to make fluid milk cheaper especially for the poor. This reduction also can minimize the influence of the "black market". In India an additional reduction of the milk price was achieved by decreasing the fat percentage of double toned milk from 3.5 to 2 per cent. The price ratio between normal buffalo milk and toned or double toned milk is 4 : 2 : 1, whereby the protein content in all three milks is almost the same (18, p.44; 36, p.20 and 79).

It is very interesting to note that in developing countries flavoured milk reached some importance. In Israel five different varieties of flavoured milk are on the market (cocoa, coffee, orange, raspberry and peppermint (26, p.18)); in Bombay there are even ten varieties on the market. The processing of these products is not connected with any special difficulties (26, p.18).

IV Milk Distribution

In developing countries the milk dealer is a massive obstacle to a fair distribution of quality milk. A regular milk market, however, is absolutely necessary if a good development of milk production as an essential part of a people's economy and nutrition should take place (14, p.21). All over the world bad experiences were had with milk dealers in developing countries so that state regulations had to be issued. Since most of the dealers also collect milk, care has to be taken that the whole milk market from the producer to the consumer is regulated by law. In the first phase of the development, organizing the market by the dairy seems to be the most suitable; this has always been proposed by experts in different developing countries, as in Iran (20, p.49). On the otherside extreme difficulties exist with the shipment and the marketing of milk because of the road conditions especially after rainy seasons. Very often the trucks at the collecting place cannot operate any more, so that transport by man or animal has to be provided.

In Israel milk is directly delivered by the dairy to the consumer's house. As far as I am concerned, in India milk delivery is very well organized. In Delhi as well as in Bombay the dairies have their own distribution system. For instance 1,000 milk depots are open daily for two hours in Delhi, operated by students. In addition 50 shops are open all day long. In Bombay 234 state distribution depots with a simple but effective equipment are planned. In these special cases it also is possible to sell unpackaged milk, so that bottles or other packages can be spared; that also means shipment of milk in small tanks. At the depots simple measurement devices for ¼, ½ and 1 litre would be enough. An additional advantage is that the price of milk is determined by the state so that phantasy prices as in Taiwan (10, p.31) are stopped.

Conclusions

Because of the deficiency of animal protein in developing countries one has to welcome the activation of milk production. However, the increase in milk production cannot be considered without thinking of the medical and veterinary aspects in developing countries, because of repercussions on public health. On the otherside it is well known that milk can cause a variety of diseases. The methods of milk preservation cannot uniformly be proposed for all developing

countries, because the distribution of milk is handled in different ways. The transfer of milk from the producer to the consumer can be direct, but also through a dealer, through a collecting place or through a dairy. According to the possibility chosen the kind of processing has to be determined. The situation is especially difficult in countries with strongly separated rainy and dry seasons, since milk production is stopped for a while. From this fact, requirements are derived for pasture farming and feed preservation, which have to go along with an increase in milk production.

In the first phase of the development of a dairy industry one cannot but organize the collection as well as the marketing of milk by the state or state authorized organizations, since the dealers oppose most of these systems. In general milk will be pasteurized as in the countries with well operated dairy industries, whereby one has to ask for an expensive cooling chain from the dairy to the dealer and to the consumer. Therefore sterilization - especially ultra-high-temperature treatment, combined with modern and economic plastic packages - is particularly recommended for developing countries. According to FAO standards, H_2O_2 preservation should only be applied in extreme cases.

Considering the special situation of milk production one should not begin in the first phase with large dairy plants in developing countries, but rather be first satisfied with collecting places. Only if minimum capacities of 5 - 10,000 kg milk per day are reached, the build up of a dairy plant should be taken into consideration. The calculation of the daily shipped milk in a region is very complex and should be manifested by thorough local investigations.

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