

Science and camel's milk production

(Some keys for nutrition and marketing)

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Abstract. Camels can lactate even under severe drought conditions. This communication describes how the camel is able to retain lactation even when dehydrated and when other milk-bearing animals perish. Not only is lactation preserved but the quality of the milk under drought conditions is admirably suited to human requirements. The mechanisms governing milk production are described. Besides milk production of amounts up to 20 litres a day or more, other aspects which make the milk specific are discussed. These aspects are: the logistic problems associated with camel's milk production; the requirements for maximal milk production; the uses of camel's milk besides for drinking; the need for pasteurisation of camel's milk; the medicinal properties of camel's milk; if camels is a unable product, why then re the production systems of the nomads considered as primitive? The scientific input is answering all of these questions is important and will help in elevating the status of camel herders in all arid lands. It is concluded that the inherent ability to provide milk in times of drought, can be utilized to provide much needed food for children who would otherwise succumb to malnutrition and even food aid which is not suitable for them. The years of misconception that camel herders are "primitive " have worked against the acceptance of camel's milk as a suitable source of seeking ways to make people self-sufficient in food production.

Key words: Dromedary, Caelus dromedaries, lactation, milk product, colostrums, human feeding, child feeding, therapy, Israel.

| Introduction

The most frequently asked question is "how much milk does a camel give, compared with a cow?" The answer is not always easy if one is not familiar with all the animals concerned, and misleading information in the past has often led to the conclusion that the camel has no role to play in modern farming. When writing about camel's milk it is imperative to stress that the most important point is that "the camel is not a cow" and should not be compared with a cow. This communication concerns the one-humped camel, the dromedary (*Camelus dromedaries*) and not the two-humped camel, the Bactrian (*Camelus bactrianus*). Although they are both camels, the physiological adaptation is entirely different: dromedaries are adapted to hot arid lands, camels are adapted to cold, arid lands. The difference in environment affects the type of milk produced. It is important to ensure that the questioner understands that the milk production of a camel the one-humped desert species-takes on special significance in the drought-stricken, famine-rife areas of the world, where cows have difficulty in surviving, and camels let alone for producing milk (YAGIL, 1984). In consequence, often even meagre amounts of camel's milk can make the difference between life and death.

Camels were first domesticated come 3,000 years ago their milk (EPSTEIN, 1971) and for use as pack animals. However, their use as pack animals was discontinued after the end of the First World War when armies became mechanized, and pack animals fell into disrepute. Camels were then relegated to being "animals of primitive

societies". Publications by KNOESS (1977) and YAGIL (1982) were not convincing enough to warrant large-scale acceptance of the camel as a farm animal. The main reason for this was that the experts in large governmental organizations are more familiar with cows and find it difficult to accept that a "primitive" animal like the camel can be a good producer of milk, even better than cows and goats. This means that virtually nothing was done to utilize the milk production if camels, especially in the drought stricken lands where the milk could have played an important role in feeding children. So the "Great Drought of Africa" (1984) and the "Long Drought of Africa" (1990-1993) were palliative handled by the industrialised countries by flying, or shipping, food, which was often foreign to the palates of the local population and indigestible, by the children (YUVAL, 1992). Camels, which are tylopodes and not ruminants, were virtually unaffected by drought. The only problems encountered by the camels were caused by a lack of salt and intestinal parasite infestation (personal observations).

At an international conference of the Physiological Society held in Budapest in 1980, a paper was presented describing the scientific rational of the camels as a farm animal (YAGIL and ETZION,1980). The presentation was well accepted by the scientific community but still did not activate development of camel farms by the agricultural community. Slowly this has changed as more and more information has become available. The importance of this symposium in Mauritania will be to gather all available data on milk production of camels to formulate a multi-national approach for disseminating the data. This present communication will present scientific data showing the importance of camel's milk in arid lands especially in times of drought when other ruminants cannot survive. The communication stresses the need for academic involvement in camel farming.

In orders to convince policy makers of the agricultural benefits of camels the following information is necessary:

- Does the camels maintain lactation in times of drought?
- Are there logistic problems associated with camel's milk production?
- What is required for maximal milk production?
- What are the uses of camel's milk?]
- If camel's milk is a usable product in modern society, why are nomads considered primitive?

| **Materials and Methods, Results, Discussion**

Camel lactation in times of drought

In drought-stricken areas ruminants are inferior to camels because of their physiological dependence on large amounts of water for metabolism and cooling (YAGIL, 1984). In these areas they are also negatively affected by other circumstances such as: extreme heat in the day, cold at night; extreme solar radiation; brackish surface water die to evaporation; poor quality and sparse vegetation. Under these circumstances, sheep, goats, and cattle stop lactating and eventually die if shade, fresh after and good fodder are not available. In Wajir, in the north-eastern areas of Kenya, over 85% of the ruminant population perished in the drought of 1990-1992.

Water deprivation and milk production

Six camels belonging to a Bedouin were milked three times a day and the amounts of milk recorded. The camels were in their third months of lactation.

RESULTS

The average volume of milk was 9.2 ± 0.6 litres per day, evenly divided between milkings. It must be noted that the letdown is for a limited period and an inexperienced milker will have difficulty getting out milk in this period. During the day the calves had free access to the udder and were observed drinking every few hours throughout the day.

Calf requirements

Six female camels in the fourth month of lactation were studied. The amount of milk drunk by a calf was estimated using methods for determining milk volumes of animals, which are difficult to handle, like primates, based on the dilution of blood by milk (water). Calves were injected with tritiated water and blood samples were taken each day. The natural decay of tritium in blood was previously determined. The studies were carried out when drinking water was readily available and following 7 days of dehydration.

RESULTS

The four-month old calves drank an average of 6 litres per day. When adding the amount of milk consumed by the calf to the amount milked, the daily milk production reached approximately 15 litres a day.

Water deprivation and milk quality

The lactating camels were subjected to 7 days periods without drinking water. At the end of these periods they were allowed free access to water for 2 hours after which the water deprivation began again.

Water, salt, vitamin C, Ph fat content of the milk was examined by standard laboratory procedures.

RESULTS

The most striking finding was that the milk became more diluted due to the dehydration, over 90% water with low fat, about 1%. The salt (NaCl) content of the milk was significantly ($P < 0.001$) elevated from 10 ± 0.4 to 23 ± 2.6 meq/l. Vitamin C content was 28 ± 3 mg/l. The Ph was low (6.3 ± 0.4) and virtually unchanged during water deprivation.

DISCUSSION

Camels continue lactating during times of drought because water is not absorbed from the mammary gland in order to conserve body water. In fact the milk becomes more diluted, a phenomenon which is hormonally controlled (YAGIL, 1988). The lack of drinking water increases the secretion of aldosterone and vasopressin, the hormones governing salt and water metabolism, leading to the conservation of water and salt. This occurs when these hormones regulate homeostasis but when they regulate homothermia, water is lost from the skin for evaporative cooling. As the mammary glands have the same ontogeny as sweat glands, the effect of vasopressin also causes water secretion from the mammary glands, hence diluted milk. This phenomenon was also found in rats exposed to heat and treated with vasopressin; instead of milk being concentrated it became diluted (ETZON and YAGIL, 1981). In addition, vasopressin in large concentrations acts on the kidneys and mammary glands as oxytocin and vice versa (YAGIL, 1985). Therefore, dehydration in fact leads to added water secretion and hence protects milk volume while diluting milk. This is also the reason why attempting to stop lactation by restricting drinking water in women or dogs fails - lactation is retained or even enhanced. This hypothesis was further reinforced by the finding that diluted milk in cows was caused by increased vasopressin concentrations when the animals were allowed only a fraction of the daily water requirements (YAGIL et al., 1986). Dehydration in camels led to an increase in salt content, thereby providing the calves with essential salt for metabolism.

These facts are important when considering using camel's milk for various products as the state of hydration will affect the composition of the milk and, hence, the product itself.

KNOESS et al. (1086), showed that camel were producing milk volumes from 17 to 26 litres per day and that after one year these volumes were often unchanged or only slightly lowered (11 to 26 litres). Lactating camels still maintained lactation capabilities after one-and-a-half years in spite of participating in various research projects (YAGIL, personal observation). These projects the insertion of balder catheters, vinous punctures too be carried out many times a day and also periods when the camels we subjected t water deprivation for 14 days a time.

The low Ph of camel's milk appears to be correlated with the high vitamin C content, giving the milk its sweet taste, which can be masked if the animal eats salty or bitter vegetation. The PH is much lower that for cows (6.8) or women (7.6).

The stories of desert travellers taking milk came with them are, therefore, based on the fact that the amounts of milk are virtually unchanged during a long, stressful march. In fact the milk is diluted, making it a good source of nutrition for the travellers. This is in striking contrast to the ruminants, sheep, goats and cattle, where the lack of drinking water leads directly, and quickly to a decline n milk production (KONAR and THOMAS, 1970).

The rapid let-down of milk in camels has been recognized by pastroalists who normally milk with two people simultaneously, one on each side.

CONCLUSION

The physiological or evolutionary adaptation of she- camels to aridity allows them to continue providing milk while the quality changes in order to guarantee life for their young, but is also admirably suited for human consumption. The camel can produce high volumes of milk and so should be selected for milk production.

All of these scientific data confirm the words of the Koran that when people were suffering in the hot climate God save them:

"...the she-camel to drink of its milk" (KHAN, 1974).

Colostrum

It is necessary to provide some information about camel's colostrums. In some parts of Africa, colostrums is not drunk by the claves as the pastrolists believe that it contains poison (Saidi, 1992). This prevents calves from acquiring basic antibodies which are essential for the well-being and would account for calf deaths. It appears that when a Chief drank the milk directly after the she-camel gave birth he was struck with severe stomach cramps and, hence, its relegation to being spoilt on the ground as being unfit for even the calf. Camel's colostrums is not yellowish to reddish color as in cattle but white directly after parties, as normal milk, with low fat, high proteins and high ash content. It is highly cathartic, which brings the calf's alimentary tract into physiological activity. Over 200 camels were examined and the colostrums described by OHRI and JOSHI (1961) as being yellowish-white with abnormal odor were never seen. ABU-LEHIA et al. (1989)in their studies of colostrum do not mention the color or smell.

Logistics associated with milk production

It has become clear that camel can provide milk in times of drought when it is often the only food available, especially for children. As an example of the importance of camel's milk let us consider the area of Wajir in northeastern Kenya bordering on Somalia and Ethiopia. In this area alone there are 120,000 camels (CHEGE, personal communication). If half are females and they would provide only 5 litres of milk a day this would mean a daily production of 3000,000 litres. If 1 litre per day would be given to every starving child, then 300,000 children could be kept alive. A theoretical, highly imaginative idea or a practical proposal?

At a camel forum held together with the camel pastorallists in this area in June 1993 (SPAETH, 1993) it was clear that they were providing milk for home consumption. After learning of the monetary compensation that could be derived from selling their milk, they asked for information on ways of improving lactation of their animals in order to provide more milk and thereby increase their income. This could be achieved by improving milking practices and treating animals for internal and external parasites. However, the logistics of getting fresh milk to the market must be solved, as well as possible friction caused by competition between herders for sales. The authors' idea was to set up a marketing office in the framework of a "Camel Centre". The "Centre" would handle the sale of milk and meat while also providing a place for purchase of medications and experts to advise the herders on keeping their camels in the best condition. The camel centre would also provide a mobile extension service as well as top grade males for serving local females, show ways to plant fodder crops and find solutions for problems which would depress milk productivity.

What is required for maximal milk production?

Genetic make-up

The genetic potential of camels can be improved by selection, artificial insemination (using good bulls) and even embryo transfers using the best females as donors and the poor milkers as surrogates (YAGIL and VAN CREVELD, 1993).

Healthy animals

Healthy animals will provide maximum milk yields. As little is known about treatment of camels, the choice of drugs and dosages are normally based on treatment regimens of cattle horses. Treatment of sick camels with drugs developed for ruminants or horses do not always give the desired result because of the camel's physiological ability to conserve water by radial changes in body water distribution (YAGIL, 1985). Therefore, intramuscular injection of some drugs does not heal the camel as the drug remains in the periphery (BEN-ZVI ET AL., 1994 ; YAGIL et al., 1994). Intravenous injections can also have unexpected results due to the decline in both renal (YAGIL, 1993) and hepatic (BEN-ZVI et al., 1989) function, the two paths of drug will increase its activity time in the body and further injections will elevate the concentrations to lethal levels.

The best way to treat a sick camel is to give from 50 to 100 litres of 3% salt solution by gavage directly into the rumen before treatment. The choice of drugs should then be based on the probable cause of the infection and drug availability. Long-acting oxytetracyclines have been showing to remain active for 5 days after a single intramuscular injection, a period which normally suffices to get the camel "on its feet" and two further injections every 3-5 days are enough to cure the animal (YAGIL et al., 1994). If possible milk from the treated animals should not be used for human consumption for 5 days after the last treatment.

Milking Machines

In general. It is difficult to visualize milking machines for camels because of the great availability in shape and size of udders and teats. However, if milking machines are introduced this will give impetus for the camel herders to bred towards standard sized udders and teats. Over 100 camels belonging to the Abu-Rabiya tribe in the Negev have udders and teats, which are well-formed for milking machines. In other countries there certainly are those who could conform to standards that can be set and used as demonstration material. In Kazakhstan, although milk production is not only lower than dromedaries but only persists for 5 months (BORODIN, personal communication) milking machines have been used in the past. Milking machines will not only guarantee higher milk productions and better milk quality but also improve the social status of camel farmers.

Uses of camel's milk

The main use of camel's milk will. Of course, be for drinking. However, as soon as production is higher than consumption, other ways of preserving and marketing camel's milk products must be found. Soured milk products are the most common milk products of all mammals.

Pasteurisation or not?

One of the questions about camel's milk is whether it should be pasteurised or not. Often unfounded statements are made that pasteurisation is a "must" for camel's milk, probably based on the fact that camels are normally dusty and their environment dirty-looking. However, the literature does not reveal milk-borne diseases among camel-milk-drinkers while many stories have been told about the medicinal properties. It was, therefore, decided to examine camel's milk in the same way that cow's milk is checked.

MATERIALS AND METHODS

Udders were cleaned with soap and water after which the teats and udders were wiped with an iodine solution. Hands were cleaned with alcohol and sterile gloves were used. Milking was done into sterile containers and immediately cooled. Samples were frozen until examination.

Bacteria content of the milk samples were examined in the Microbiology Department of the Veterinary Institute, Bet Dagan, using standard laboratory techniques. Specific tests for *Staphylococcus* spp. And *Streptococcus* spp. were used: Pladebact *Staphylococcus* test and Pladebact *Streptococcus* test (Karo Bio Diagnostik. A.B. Huddinge, Sweden).

RESULTS

Besides bacterial normally found in the mouths of calves no pathogenic bacterial were found in any of the samples. Fecal cocci appeared in the milk only once, coming from the hands of a camel herder who helped in the milking.

DISCUSSION

One particular problem associated with camel's milk marketing is the question: " Is there a need of pasteurisation" . The answer seems fairly simple but in fact has given rise to much controversy. It must be considered that pasteurisation was initiated to rid milk of harmful pathogens, especially tuberculosis. Besides the fact that camel's milk has been used to treat tuberculosis (DONCHENKO et al., 1975), all camels that are milked are checked for tuberculosis, which can easily be done in every country. Other pathogens like brucella, pasteurella, etc. can be checked, in the same way as for tuberculosis, before marketing the milk. If all camels are healthy there is no need for pasteurisation. Mare's milk from Kazakhstan is exported to West Europe without pasteurisation in order not to destroy special qualities of the milk (DUISEMBAEV, personal communication) as the mares have been proven to be free of pathogenic infection there is still a resistance to drinking unpasteurized milk. The resistance is normally based on the

(mis) conception that camels are dirty animals and, therefore, must harbor diseases. However, it must be noted that camel udders are not normally cleaned before milking and the hygiene of the milkers is such that there is always a chance of bacteria from their hands entering the milk. So when considering the marketing of camel's milk basic hygiene practices must be introduced, although this applies to all products marketed by farmers in the developing countries. Milking machines would improve the hygiene of milking practices.

Cream and Cheeses

The Jewish Talmud states that if a religious person wants to purchase milk he must make sure that it isn't camel's milk which is not kosher but he does not have to check when buying cheese or butter because they cannot be made from camel's milk. Modern technology has allowed these products to be made, and in Paris at the Conference on Reproduction of Camels in 1990, camel's cheese was brought from Tunisia. The main problem in making cheese was brought is the fact that a coagulum is only poorly formed when camel's milk comes in contact with acid or pepsin. The fat composition of camel's milk fat (ABU-LEHIA et al., 1989; FARAH, 1993).

Separation of cream requires 5-6 days under refrigeration and must be repeated to obtain a good yield (WANGO, 1993) compared with several hours for cow's milk (ABU-LEHIA, 1989).

Using modern techniques, cheese can be prepared and there is even a cheese-making kit available. It should be noted that as far back as 1985 a Swiss lady, Ms Gower, successfully made cheese from camel's milk in Kenya.

Medicinal Purposes

There are many folklore stories told by camel herders describing the use of camel's milk for medicinal purposes or as a health food (YAGIL, 1982). In many cases research carried out in the former Soviet Union showed that camel's milk was superior to mare's milk, which in turn was superior to milk of other animals. Mare's milk is being exploited at present in Germany for medicinal purposes (DUISEMBAEV, personal communication). It has been shown that camel's has antibacterial and anti-viral properties (EL-AGAMY et al., 1992), which conform with previous data that camel's milk destroys *Mycobacterium tuberculosis* (DONCHENKO et al., 1975). The laboratory of the authors has begun checking the scientific validity of the stories.

DIABETES

The authors personally have heard from Bedouin that they treat their diabetes by drinking camel's milk. There were even cases of juvenile diabetes being stabilized on camel's milk when insulin treatment had failed (LIBERMAN, personal communication). It was found that one of the camel's milk proteins is similar to insulin (BEG et al., 1986).

The authors used a specific antibody to insulin in a RIA test for insulin (Coast- A-Count, Diagnostic Products Corp., Los Angeles, USA) in camel's milk and discovered large concentrations of insulin: 40 units/l.

Most sceptics to the anti-diabetes activity of camel's milk maintain that as insulin is a protein it will be destroyed by acid in the stomach especially as milk forms a coagulum in the stomach, allowing acid and pepsin to break down proteins over a period of time. However, the "disadvantage" of camel's milk is that it does not form a coagulum with acid (ABU-LEHIA, 1989) and is difficult to coagulate with rennet (WANGO, 1993) and so cheese making is difficult. This lack of coagulum formation allows the camel's milk to pass rapidly through the stomach, together with the insulin. Even if some insulin will be destroyed enough will be available for absorption.

Another study was carried out on rabbits fasted and water-restricted for 25 hours. These rabbits showed a decline in blood sugar after camel's milk administration, suggesting that insulin activity was the cause. Although Bedouin are

known to treat their diabetes by drinking camel's milk, more research is required before a final conclusion can be reached or before human studies can be carried out.

LIVER PROBLEMS

In Asia, it was shown that camel's milk had a beneficial action on chronic liver patients (SHARMANOV et al., 1978). Based on this fact, camel's milk was given to a young child with biliary atresia (lack of tube carrying bile from liver to gall bladder) whose diet consisted only of cow's milk and whose condition was rapidly deteriorating. The deterioration was diminished and the child remained in good condition until a Liver transplant was performed. It is quite possible that the relatively high concentrations of vitamin C in camel's milk, as also described by FARAH ET AL. (1992), aids in the improved liver function.

SUPPLEMENT FOR BREAST FEEDING

It is estimated that worldwide there are 145 million malnourished children and from 4 to 5 million deaths due to diarrhoea each year (UNICEF, 1992). Over 80% of these deaths occur in children under 2 years of age. Research is underway to examine the use of camel's milk as a supplement to mother's milk or as an alternative to formula in order to provide a nutritious fresh milk in areas prone to diarrhoea due to bad hygienic conditions.

GENERAL FATIGUE

An adult man requested camel's milk from the authors to relieve his chronic fatigue as he had not worked more than 2 hours a day for the past 2 years. He had tried all kinds of treatment but nothing worked and medical checks could not find what was ailing him. After drinking camel's milk he immediately felt well and for a period of 6 months (to date) he drinks milk every few days and now works a minimum of 8 hours a day. The authors have considered that they were seeing a psychosomatic reaction. However, this man told of the "filling effect" of the milk i.e, a feeling of satiation lasting up to 10 hours after drinking the milk, a phenomenon often described by the Bedouin. He also "complained" about added sexual prowess, another side effect of camel's milk known to the Bedouin but not beforehand to this milk drinker. This person can also feel the differences in the effect of fresh milk and frozen milk.

Why are camel herders considered primitive?

This observation is true for herders all over the world. The main reason for downplaying the role of camels is the fact that they are mobile and present a (so-called) security risk for the host country. The mobile homes and lack of property also relegate the people to being "primitive". In fact society envisions town-dwellers as being the most advanced, the descending via cattle, then sheep and goat herders to the lowest, and hence "primitive",. They live in harmony with their environment and have a rich culture, which also includes aspects of "alternative medicine".

| Conclusion

It does not require a scientist to discover that pastoralist in draught-stricken areas are receiving milk from their camel when other food providers have succumbed to the environmental stresses. Nevertheless, the role of camels as food providers has been neglected because of the common misunderstanding of comparing camel production to cow production in the temperate climates. Even then the production of camels can be formidable. There are, however, many camels with low milk production because of bad selection practices over many decades, which have increased the genes for poor milkers, increasing the numbers of bad producers. However, even poor milkers producing up to 5 litres of milk can still provide sustenance for 10 children because of the "filling effect" of the milk. The scientist can provide facts and figures, which verify the ability of the camel to sustain milk production. Research has shown that the

one limiting factor in camel health is salt (YAGIL, 1985). The physiological integrity of camels in drought is depend on salt intake. Sometimes the soil lacks enough salt and if blackish water is not available, camels will result to eating anti hills in their endeavour to find salt (YAGIL, personal observation). The role of science in camel's milk farming is one of the problem solving. It is necessary to carry out research in those areas of milk production, which are problematical as well as to upgrade milk production (by, technology, drug treatment and milking machine s). The years of misconception that camel herders are "primitive" have worked against the acceptance of camel's milk as a suitable source of nutrition, but that is changing in the present climate of seeking ways to make people self-sufficient in food production.

To quote the nomadic tribe of Ahaggar in the Sahara: "Water is the soul. Milk is life."

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