



## **CHAPTER 1**

### **1. General introduction**

About 25,000 people die every day of hunger or hunger-related causes, according to the United Nations ([www.wfp.org](http://www.wfp.org)), particularly in Africa. In Cameroon life expectancy at birth is estimated to be 51 years. In 2006 the under-five mortality rate was 150 deaths per 1,000 live births. Poverty is rampant in the country as 50% of the population live below the national poverty line (World Bank, 1999). Prevalence of malnutrition increased from 16% to 23% between 1991 and 1998, rising from 13% to 15% in urban areas, and from 19% to 25% in rural areas (Pongou *et al*, 2005) with a prevalence of 22% in children less than 5 years of age. One way of combating extreme poverty is to improve agricultural production because about 75% of the active population is involved in agriculture, which accounted for 50% of total exports (Wolfgang, 1997) and about 22% of GDP in 2000. The dairy cow is known to be one of the smartest investments a farmer can make in terms of income generation (ILRI, 2003). Due to urbanization and population growth, milk production should double by the year 2020 if it is to meet demand (Ndambi *et al*, 2006).

Already, self sufficiency in milk products in Cameroon only stands at 76%, while 24% of the national consumption is imported (Ndambi and Bayemi, 2006). Therefore, there is a need to improve domestic milk production (Figure 1.1).

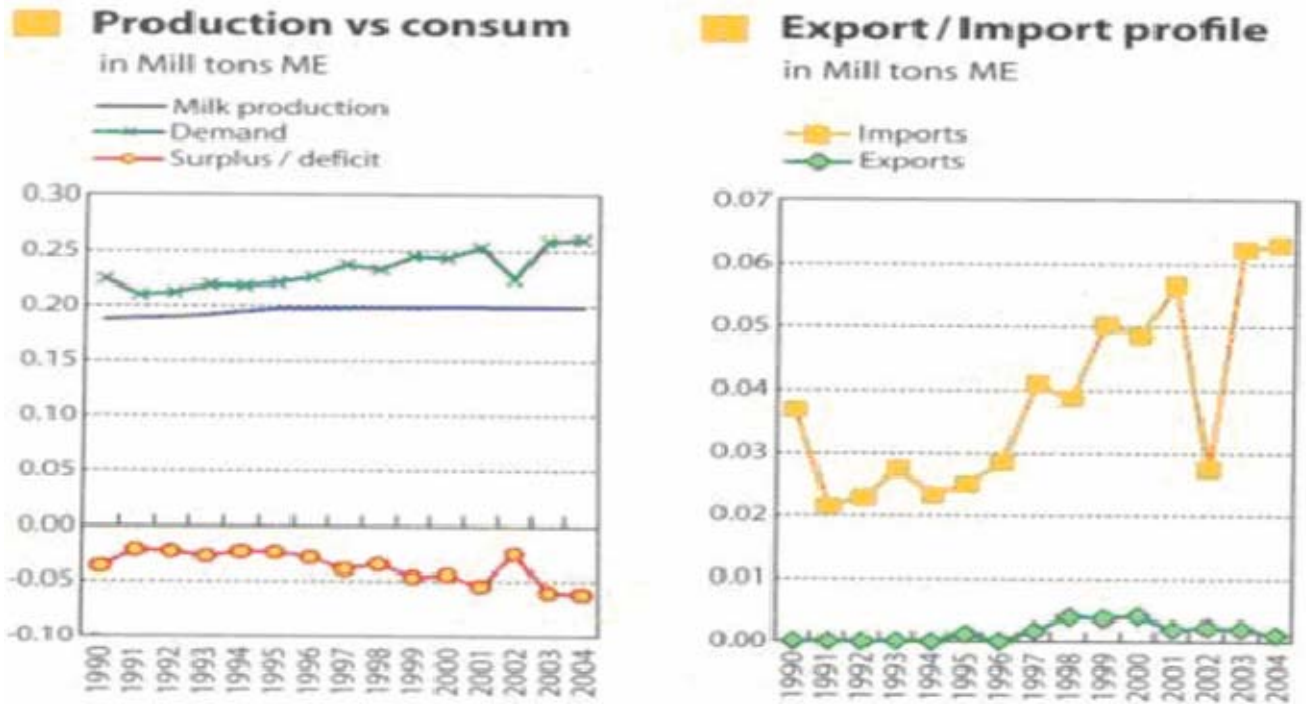


Figure 1.1. Production vs consumption and import/export profile of milk production in Cameroon, in million tons ME (ECM) (Ndambi *et al*, 2006)

The Republic of Cameroon is located in Central Africa and ranges from the equatorial forest to the Sahelian zone in Lake Tchad with a total land area of 475 440 km<sup>2</sup> and a human population of 16.2 million (Ndambi *et al*, 2006). The population is expected to reach 20.5 million in 2010 (Njoya *et al*, 1999). It is administratively divided into 10 regions covering five agro-ecological zones. The four administrative regions that have been particularly associated with dairy production in Cameroon are the Adamaoua, North, Far North and the North West. The latter is more suitable to dairy production as it has milder temperatures and is free of Tse Tse flies.

Three systems have been associated with cattle production in Cameroon. First, the extensive or traditional system which for centuries has been carried out by the Fulani pastoralists; in this system, milk is considered as a by-product of beef production using breeds such as the Gudali, Red Fulani and White Fulani (*Bos indicus*). The animals graze on native pastures of *Sporobolus africanus*, *Pennisetum purpureum* and *Melinis multiflora*. Milk off-take starts from 1 to 3 months post-calving and varies between 0.5 to 3 litres per cow per day. Calves are usually weaned at 10.5 months. In the semi intensive systems, crossbred animals are used (*Bos taurus X Bos indicus*). Fencing is common as is rotational grazing. Pastures are improved with planted grasses, legumes and multipurpose trees, including grasses like *Brachiaria spp*, *Trypsacum laxum* and *Pennisetum clandestinum*. Cattle are also fed on by-products, waste food and fruits such as sugar cane leaves, potato leaves, guavas, ripe bananas, pumpkins and waste cooked corn. Crop residues include: corn stovers, banana pseudo stems and leaves, ground nuts and bean haulms. In this system cows give an average of 12 litres per cow per day at the peak of the lactation curve. The intensive system involves the use of purebred Holstein cattle in a zero grazing, cut and carry system, at often 1 to 2 cows per farm. The following ingredients are commonly used in supplementation on semi intensive and zero grazing cows: Maize, rice bran, wheat bran, palm kernel cake, cotton seed cake, whole soya

beans, bone ash, limestone and table salt. Purebred calves are given colostrum, then bucket fed and weaned at 4 months of age. At peak lactation, cows can produce up to 25 litres per cow per day.

Constraints to dairy production in all systems include: low nutritive value of pastures and inadequate pasture management (Njoya *et al*, 1999); unavailability of dairy cows, long calving to conception periods, low heat (oestrus) detection, presence of ticks and tick-borne diseases, high cost of veterinary services, lack of cooling facilities for milk, the poor access of farmers to resources and information (Ndambi *et al*, 2008), limited milk for processing and consumption in urban areas.

These constraints limit milk production which declines at 1% per farm per year (Ndambi and Bayemi, 2007). There have been a number of results from studies aimed at improving small scale dairy production based on improved feeding, reproduction, health and management (Mbanya *et al*, 1995; Kamga *et al*, 2001; Bayemi *et al*, 2005a; Bayemi *et al*, 2005b; Ndambi *et al*, 2006; Bayemi *et al*, 2007).

However, the uptake of these results by wider communities of farmers, farmers' organizations and livestock extension services has been less than expected. It is becoming clear that the major reason for this is a failure to demonstrate the advantage in economic terms to the farmer because emphasis was on biological improvements. In addition, previous initiatives failed to show the farmer the real gains that could be made, because they focused only on one constraint at a time, and other concurrent production problems limited the economic benefits. This in turn resulted in interventions for supplementary feeding, or for improving reproductive performance that did not demonstrate an economic benefit to the farmers. Therefore there is a need for the development of an integrated approach that addresses the

major production constraints simultaneously, generates significant profit (Perera, 2007) and ensures sustainability.

This development requires a comprehensive knowledge of milk production systems in the country, an investigation in reproductive and feeding problems, a study on the milk quality and an attempt to solve the existing constraints by applying specific interventions. The research was conducted within the framework of a thesis. The results are presented as articles on specific topics, most of which have been published in scientific journals with peer review.

The main objective of this work is to develop an integrated method to ensure sustainability and improve dairy farms. Work on specific objectives is reported in chapters on: the review of studies on milk production in Cameroon; the participatory rural appraisal and economic opportunity survey of dairy herds in Cameroon; the study of progesterone profiles of cattle breeds used for milk production; investigation on the effect of pre-partum supplementation on post-partum ovarian activity; study on brucellosis; setting up of interventions aimed at improving milk production and an evaluation of the impact of these interventions.

## References

- Bayemi, P.H., Bryant, M.J., Perera, B.M.A.O., Mbanya, N.J., Cavestany, D., Webb, E.C., 2005a.** Milk production in Cameroon: A Review. *Livestock research for rural development* 17 (6). [www.cipav.org.co/lrrd/lrrd17/6/baye17060.htm](http://www.cipav.org.co/lrrd/lrrd17/6/baye17060.htm)
- Bayemi, P.H., Bryant, M.J., Pingpoh, D., Imele, H., Mbanya, J., Tanya,V., Cavestany, D., Awoh, J., Ngoucheme, A., Sali, D., Ekoue, F., Njakoi, H., Webb, E.C., 2005b.** Participatory Rural Appraisal of Dairy Farms in the North West Province of Cameroon. *Livestock research for rural development* 17(6).  
[www.cipav.org.co/lrrd/lrrd17/6/baye17059.htm](http://www.cipav.org.co/lrrd/lrrd17/6/baye17059.htm)
- Bayemi , P. H., Webb ,E. C., Manjeli ,Y., Naoussi , P., 2007.** Economic Opportunity Survey of Small Scale Dairy Farms of the North West Province of Cameroon. *Tropical Animal Health and Production*, 39:583-592
- ILRI, 2003:** Enhancing Milk Markets Vital to the Poor. International Livestock Research Institute.  
[http://www.ilri.org/ILRIPubAware/Uploaded%20Files/200481194430.02BR\\_ISS\\_EnhancingMilkMarketsVitalToThePoor.htm](http://www.ilri.org/ILRIPubAware/Uploaded%20Files/200481194430.02BR_ISS_EnhancingMilkMarketsVitalToThePoor.htm)
- Kamga, P., Mbanya, J.N, Awah, N.R, Mbohou, Y., Manjeli, Y., Nguemdjom, A., Pamela, B.K, Njwe, R.M, Bayemi, P. H., Ndi, C., Imele, H., Kameni, A., 2001.** Effect of the calving season and zootechnical parameters on milk yield in the western highlands of Cameroon. *Revue d'Elevage et de Médecine Vétérinaire des Pays Tropicaux*, Volume 54, Numéro 1, pp55-61.
- Mbanya, J., Vabi, M., Nfi, A., Yonkeu, S., Kameni, A., Pingpoh, D., Moussa, C., 1995.** Report of survey on periurban dairy production in Garoua and Maroua IRZV (Institut de Recherche Zootechnique et Vétérinaire) Yaoundé Cameroon, December 1995.

**Ndambi, A., Bayemi, P.H., 2006.** Cameroon-Dairy Sector and Chain Profile. In. Hemme *et al.* (2006). IFCN Dairy Report 2006. International Farm Comparison Network, IFCN Dairy Research Center, Kiel, Germany, p102.

**Ndambi, A., Bayemi, P.H., 2007.** Cameroon milk production facts. In. Hemme *et al.* (2007). IFCN Dairy Report 2007. International Farm Comparison Network, IFCN Dairy Research Center, Kiel, Germany, 3-19. p79.

**Ndambi, O.S., Hoffmann, V., Bayemi, H., 2006.** Stimulating Milk Production in Cameroon - Meeting the Challenges. “Prosperity and Poverty in a Globalised World-Challenges for Agricultural Research”. Tropentag, October 11-13, 2006, Bonn.

**Ndambi, O. A., Tchouamo, I., Bayemi, P. H., Hemme, T., 2008.** Milk production amongst Fulani grazers in the Western Highlands of Cameroon: Constraints and development perspectives. *Livestock Research for Rural Development*. Volume 20, Article #13.  
<http://www.cipav.org.co/lrrd/lrrd20/1/ndam20013.htm>

**Njoya, A., Mbanya, N. J., Nguemdjom, A., Kamga, P., Ndi, C., Kameni, A., Nfi ,A. 1999.** Cattle productivity on smallholder farms in the western highlands of Cameroon. In *Development of feed supplementation strategies for improving the productivity of dairy cattle on small holder farms in Africa*. Proceedings of Research Coordination of a Coordinated Research Project organized by the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture held in Vienna, Austria, 7-11 September 1998.

**Perera, B. M. A. O., 2007.** A Coordinated Research Programme to develop methodologies for an integrated approach to improve small scale market oriented dairy systems in developing countries. *Tropical Animal Health and Production*, 39,543–548. DOI:[10.1007/s11250-007-9058-5](https://doi.org/10.1007/s11250-007-9058-5)



**Pongou, R., Joshua, A.S., Majid, E., 2005.** Economic Crisis and Declining Child Nutrition in Cameroon During the 1990s: The Mediating Role of Household Effects. Harvard Center for Population and Development Studies.

**Wolfgang, G., 1997.** The soil fertility replenishment problem from a private sector point of view: keynote presentation at the workshop held in Nairobi, June 3-9 1997: Attachment 1. Working Paper Series. Volume 15 Number 2. July 2005.

**World Bank, 1999.** Update of the Cameroon poverty profile. World Bank. (In process).

MINEFI (1996) – National Household Survey, Yaoundé.



## CHAPTER 2

### 2. Literature review

#### Milk production in Cameroon

Published in Livestock Research for Rural Development

Bayemi, P.H., Bryant, M.J., Perera, B.M.A.O., Mbanya, N.J., Cavestany, D., Webb, E.C., 2005. Milk production in Cameroon: A Review. Livestock research for rural development 17 (6). [www.cipav.org.co/lrrd/lrrd17/6/baye17060.htm](http://www.cipav.org.co/lrrd/lrrd17/6/baye17060.htm)

## 2.1. Abstract

For centuries, milk production in Cameroon has been characterized by the traditional system using local zebu cows (Gudali, White Fulani, Red Fulani). However, this production has been insufficient reaching only an average of 3 litres per cow per day. Per capita annual consumption was 10kg in 1984. Since then improvement in production has been possible thanks to importations of high yielding breeds such as Holstein Friesian, Jersey and others. This gave room to other semi intensive and intensive production systems in such a way that in 1998 per capita production was 12.8kg. This is still far below 34kg per person for Africa and 294kg per person for Europe. In this study, research done in the area on milk production was reviewed. Constraints to increase production were summarized and proposals are made for the sustainable development of the dairy sector

**Key words:** Cameroon, cattle, dairy, milk, review

## 2.2. Introduction

Africa's human population is growing at a rate of 3.1% per year (Ndituru, 1993). This population growth is prompting many governments to aim at a policy of food self sufficiency. Although efforts are being made to increase agricultural production, malnutrition is still a plague in many parts of the continent. Protein and micronutrients deficiencies continue to be persistent (Delgado *et al*, 1999). Over 800 million people worldwide suffer from malnutrition and hunger not only due to low food production and unequal distribution but also because poor people lack the income to acquire adequate quantities and qualities of food (Wilson *et al*, 1995). People of Sub-Saharan Africa consume foods that consist mainly of starch and oil. Milk and milk products, if sufficiently available, could efficiently correct these deficiencies and be part of most Africans' diet. Besides improving nutrition and health of all members of the household, dairying also increases farmers' incomes (ILRI, 1998). However, in 1999, per capita production of whole fresh milk in Africa was only 34kg /person compared to 294kg / person in Europe (adapted from FAO, 2000) with very large variations of consumption among regions of the same country. Such a deficit makes milk products expensive and not available to most people. This is seen in urban areas where prices go up in the hot season because of the shortage of milk from pastoralists (Kameni *et al*, 1999). The consequence of high prices is the reduced availability of milk products for vulnerable groups (Phelan 1994). These are children and people of low income. On the other hand the milk deficit calls for imports of milk products thus leading to a considerable drain on finances. von Massow (1984) drew attention to the increase in the volumes and values of dairy imports into Sub-Saharan Africa even though these countries faced a serious shortage of foreign exchange. Dairy imports made up about half the total milk consumption in West and central Africa (Von Massow, 1989), increasing throughout the 1970s and early 1980s, at

an annual growth rate of 10% or more. Consequently, there are sustained efforts to develop domestic milk production in Sub-Saharan Africa (Walshe *et al*, 1991).

Formal research on dairy cattle started in Cameroon in the early 1970's (Tchoumboue and Jousset, 1982) on imported and local cattle. However, there is no comprehensive report available providing information on the key aspects of the research done on this topic in Cameroon to this day. In Sub-Saharan countries, because of inadequate available literature, there is always a risk of duplicating research and therefore wasting time and resources. There is also a need for information to be gathered on the subject and made available to policy makers. Consequently, this paper reviews and discusses work carried out in Cameroon in relation to dairying, suggesting ways to improving the sector and proposing lines for subsequent research.

### **2.3. Sites of dairy cattle production in Cameroon**

The Republic of Cameroon is located in Central Africa and ranges from the equatorial forest to the Sahelian zone in Lake Tchad with a total land area of 475 440 km<sup>2</sup> and a human population of 14.693 million (FAO, 1999). The population is expected to reach 20.5 million in 2010 (Njoya *et al*, 1999). It is administratively divided into 10 regions covering five agro ecological zones. The cattle population stands at 6 million heads. Over 90% of the estimated cattle number is to be found in four regions, the Far North, the North, the Adamaoua and the North West Province (Kameni *et al*, 1999). The two regions that have been particularly associated with dairy production in Cameroon are as follows:

- The Adamaoua Plateau is situated at 1100 m above sea level. Weather conditions have been reported by Pamo and Yonkeu (1986). The climate is tropical, usually described as sudano-guinean, with a characteristic unimodal rainfall pattern. Two major seasons are prevalent, the wet season which runs from April (mean precipitations of 128.8 mm) to October (107.2 mm) and the dry

season from November to March. The maximum monthly rainfall ever recorded was 325.6 mm and occurred in July. Total annual precipitation ranges from 1392 to 1982 mm per year. Mean relative humidity and temperature are 67.3% and 22.0 °C, respectively. Minimum and maximum temperatures are 10 and 34 °C, respectively. The hottest months are from November to January. Frost is rare on the highlands. Natural vegetation is woody savannah. It is a sudano-guinean type which is interspersed with *Daniellia* and *Lophira* spp trees. Major grasses have been described by Piot and Rippstein (1975) with predominant species being *Hyparrhenia* and *Panicum* spp. The principal improved pastures developed on station are *Brachiaria* and *Stylosanthes* spp.

- The Western Highlands, another dairy producing region, is located in the mid and high altitude zone of the country which lies between latitudes 5°20' and 7° North and longitude 9°40' and 11°10' East of the Equator. The surface area of the Region is 17,910 km<sup>2</sup> covering 1/6 of the country's land area. Altitudes range from 300 to 3000 m above sea level. The climate is marked by a dry season from November to mid March and a rainy season from mid March to October. Rainfall ranges between 1300-3000 mm with a mean of 2000 mm. Minimum and maximum temperatures have means of 15.50°C and 24.5°C, respectively; although temperatures can go above 30°C. There are three types of soils: volcanic, hydromorphic and ferralitic. The human population is estimated at 1.82 million inhabitants, being one of the highest population densities in the country, with at least 79 inhabitants per km<sup>2</sup> and a population growth rate of 3.1% (Winrock International, 1992). The agricultural population is estimated at 72% with 160,025 farm families. Agricultural products from low to medium altitude include: oil palm, cocoa, Robusta coffee, fruit trees, cocoyam, maize, small livestock, rice, and groundnuts. The high altitude (above 1400m) products include: solanum

potato, Arabica coffee, vegetable and small and large ruminants (PNVRA, 2002). The region is the third major cattle producing area (500,000 cattle) after the North and the East. The main vegetation is Savannah. Pastures are dominant with *Sporobolus africanus*. But the following species can be encountered: *Pennisetum clandestinum* and *Pennisetum purpureum*, *Loudetia*, *Hyparrhenia*, *Urelytrum fasciculatum*, *Panicum phramitoides*, *Paspalum arbutulare*. Some improved species have also been introduced such as *Brachiaria* spp, *Trypsacum laxum*, *Stylosanthes* spp and tree legumes (Merlin *et al*, 1986; Njoya *et al*, 1999). The Western Highland of Cameroon is an area free of Tse Tse fly.

#### **2.4. Traditional dairy production**

In Africa, pastoralists derive up to 75% of their food needs from milk (Galvin, 1985). These pastoralists own about 50% of Africa's livestock (de Leeuw *et al*, 1995). In Cameroon, they own most of the cattle population. According to Kameni *et al* (1994), most of the available cow's milk in Cameroon is produced by the Fulani cattle men. In the Fulani tribe, cattle production is the main activity. Their life revolves around this activity and most of their income is derived from it. Crop production is marginal and is carried out by occasional labour. The cattle men practice a pastoralist type of management whereby cattle are held in the vicinity of the village or urban area during the wet season, and then taken to lower pastures during the hot months in search of better grazing (Douffissa, 1988 and 1993). In this traditional system, milk is considered as a by-product of beef production using breeds such as the Gudali, Red Fulani and White Fulani (*Bos indicus*). More than 90% of calvings occur during the rainy season (Njoya *et al*, 1999). Milk off take starts from 1 to 3 months post-calving. Calves are usually weaned at 10.5 months. A number of lactating animals are left on the camping area while the rest of the

herd is taken for grazing. Milking is all done by hand and any milk not required by the owners is either boiled and sold as liquid milk or allowed to sour naturally to provide a base for a sorghum or maize porridge (Kameni *et al*, 1999). The milk can also be used for exchange for grain. When cattle herds reside around urban centres, they represent the major, perhaps only, source of fresh milk for urban dwellers. When cattle herds reside in remote areas, only a very limited amount of milk might occasionally be sold for cash because the camping areas are usually far away from urban centres and schools. So a major constraint on the supply of milk to urban populations is the effective marketing of the supplies of milk potentially available from pastoral herds. An added complication is that the demand for milk in the urban centres is greater in the dry season than in the wet season. However, in the dry season with cows being on transhumance, pastoralists are unable to take advantage of this increased demand while in the wet season, when cattle herds may be adjacent to urban centres, demand for milk is low and prices are depressed. The opportunity to capitalize on the demand for milk, coupled to the need to promote more productive dairy systems, has led to the importation of European type dairy cattle.

## **2.5. Exotic dairy cows in Cameroon**

The first exotic dairy cattle were imported into Cameroon in the 1930s (Tambi, 1991) by expatriates. They were of the German Brown breed (Atekwana and Maximuangu, 1981). At the end of the Second World War, these cattle were replaced with Holstein Friesian cattle and an Austrian breed (Pinzgauer) in Buea. At the same time, the Montbéliard breed was introduced in Dschang and Jakiri for crossbreeding with local cattle. In 1964, a dairy experimental station was set up at Bambui (Njwe, 1984) and in 1967 Brown Swiss heifers were imported for crossbreeding with N'Dama cattle. Montbéliard semen was imported in 1975 for crossbreeding with Gudali (*Bos indicus*) females in the northern part of the country. Immediately preceding this, the Heifer Project International (HPI) signed an



agreement with the government and the importation by HPI of Jersey cattle, Holstein Friesian cattle and semen started and continues to the present time (HPI, 1999). This same organisation has trained dairy farmers to practice a zero grazing system with Holstein Friesian cows imported from Ireland since 1994. Importations of exotic cattle resulted in the development of more specialist systems of dairying.

### **2.5.1. Semi-intensive system and crop and livestock integration**

These systems of dairying use crossbred cattle with improved pasture grazing and supplements such as rice bran, palm kernel cake, wheat bran, and soya beans, all in small amounts. Fencing is common as is rotational grazing. Animals often make use of farm residues such as maize stovers, ground nut and bean haulms, rice straw, and banana forage. They are also supplemented with agro-industrial by products such as cottonseed cake, brewers grains and palm kernel cake and tree legumes such as *Leucaena* spp and other legumes (*Stylosanthes* spp, *Desmodium* spp). In the Western highlands, such systems are practiced by the Tikar (native) population (Njoya *et al*, 1999).

### **2.5.2. Intensive system of livestock production**

Intensive systems involve on the one hand a few modern commercial farms; on the other hand, the cut and carry system where animals are kept in stables and supplemented with concentrate. It is these systems which use purebred high yielding dairy cows (HPI, 1999). Small scale farmers suffer however from a very heavy work load because of the lack of machinery. Efficient ways of management need to be developed in order to lighten this burden.

## 2.6. Productivity of breeds used for milk production

Nearly all milk production studies done in the country have been geared towards cattle which supply the majority of milk. The common traditional breeds involved in dairying are the *Bos indicus* Gudali, Red Fulani and White Fulani. Their production levels are indicated in Table II.1.

**Table II.1:** Summary of breed performance of animals used for milk production in Cameroon

Breed	Birth weight, (kg)	Daily gain from 13 to 41 weeks, (kg)	Age at 1 <sup>st</sup> Calving, (days)	calving rates,%	Calving interval, (days)	Lactation length, (days)	Number of inseminations per conception	Milk yield per day of lactation, (kg)	Milk yield (kg)	Mortality from birth to 36months,%
Gudali(G)	22.5 <sup>1</sup>	0.35 <sup>1</sup>	1440	75	511	140			373	3.5
Red Fulani(RF)	21.5 <sup>1</sup>	0.43 <sup>1</sup>		76.9 <sup>2</sup>		114 <sup>2</sup>		2.4 <sup>1</sup>	513 <sup>2</sup> 295 <sup>1</sup>	4.7 <sup>3</sup>
White Fulani(WF)	22.3 <sup>1</sup>	0.27 <sup>1</sup>		76.1	444	175		2.8 <sup>1</sup>	536 465 <sup>1</sup>	4.6
Jersey( J)	16.8 <sup>1</sup>	0.39 <sup>1</sup>	924	79.5	419	315		8 <sup>1</sup>	2681	8.9 to 26
Boran(B)			600 <sup>5</sup>				2 <sup>5</sup>		315 <sup>5</sup>	
Holstein(H)	32.7 <sup>1</sup>	0.44 <sup>1</sup>	964	75.4	472	329	2.4 <sup>5</sup>	11.5 <sup>1</sup>	3202 <sup>1</sup> 3471 <sup>2</sup> 4750 <sup>5</sup>	12.7 to 38
HXG(F1)			780	78.9	399	282			1575	6.3 to 20
HXRF(f1)			927	87.5	403	221			1551	5.8
JXWF(F1)			1077	78.8	382	189			1011	5.6 to 11.5
MXG(F1)			1140 <sup>4</sup>	82 <sup>4</sup>	399 <sup>4</sup>	258 <sup>4</sup>			1380 <sup>4</sup>	44 <sup>4</sup>

M=Montbéliard

*N.B. superscripts relate to references*

<sup>1</sup>IEMVT (1975/76); <sup>2</sup>IRZ(1982,1983,1984,1985); <sup>3</sup>Mbah (1984) and Mbah et al(1987); <sup>4</sup>Tawah and Mbah (1989); <sup>5</sup>HPI(1999);

Tawah and Rege (1996) reviewed information on White Fulani cattle related to the breed's physical characters and production parameters. They described its distribution and husbandry practices and concluded that the breed is economically important for several communities in West and Central Africa. Although the population size of the breed is large, crossbreeding with exotic and local breeds poses a long-term threat to this breed. Abassa *et al* (1993), then Bayemi (1999), investigated growth performance records of Gudali cattle. The latter developed models related to the growth of calves and heifers as a help to selection. The Red Fulani breed is found in many countries of West and Central Africa; Nigeria, Chad, Cameroon, Niger and the Central African Republic. They are extremely hardy and adapt to a wide range of conditions particularly to arid zones (Maule, 1990). These local breeds have been crossed with European *Bos taurus* breeds, including the Holstein Friesian, Jersey and Montbeliard (Mbah *et al*, 1987; Tawah and Mbah 1989; Mbah *et al*, 1991; Tawah *et al*, (1999a).

Tawah *et al* (1998) studied the fixed effects of genotype, parity, age at calving, season and year of birth of cows on lactation and reproductive performance. Traits analysed were lactation milk yield, lactation duration, annual milk yield, calving interval, dry period and age at first calving. They found as expected, that in Cameroon, Holstein cows produced more milk than any other breed; exotic or local. Holstein F1 crosses were also better than any other crosses in the same trait. The season of birth of cow also significantly affected the age at first calving. This means that female calves born in times of hardship (eg: dry season), took much longer to take in a calf. Tawah *et al*, (1999b) also studied the genotype and environmental factors of crossbreeding the local Gudali zebu cows with either Montbeliard or Holstein bulls. Their study confirmed reports that F1 crosses are superior to their backcrosses in milk production in harsh tropics. The results further revealed that Holstein x Gudali F1 cows were better than Montbeliard x Gudali F1 in milk

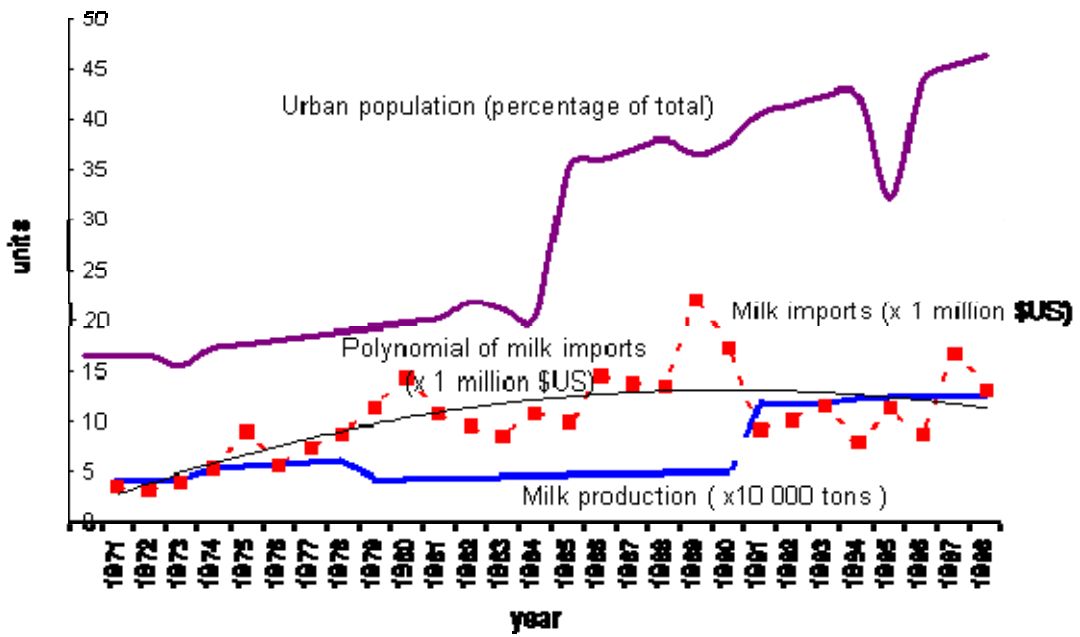
production and reproductive performance. The performance of the F2 was lower than F1 in milk production and age at first calving. The authors recommended that Montbeliard x Gudali crosses be used for dairy-beef production systems because of their dual purpose nature while Holstein x Gudali crosses may be better suited for moderately intensive dairy production systems on the Cameroon Highlands and similar environments. Kamga *et al* (2001) working with Holstein, Jersey and their crosses with Gudali confirmed the suitability of Holstein x Gudali crosses for milk production in Cameroon.

## **2.7. Domestic milk production and demand**

In Cameroon, the livestock sector represents 16% of the agricultural production in terms of Gross Domestic Production (MINPAT, 1986) and is dominated by large ruminants. The country has 6 million cattle with 4% milking cows (FAO, 1970-1999). The total number of cattle has been consistently increasing for over 30 years.

The increase in number of lactating cows in the 1990's may have been due to the new surge towards high yielding imported cows to increase domestic production. Annual per capita of milk production in Cameroon was estimated at 5.1kg (MINPAT, 1986) while consumption was estimated at 10kg / person / year by von Masow (1984). Total domestic production of milk was 50.000 tonnes (Tambi, 1991). In 1999, per capita production stood at 12.8kg while per capita consumption was 15.3kg in 1998 (calculated from FAO, 2000). In fact milk production in the country has substantially increased (from 48 000 tonnes to 184,000 tonnes). This jump occurred because of the policy carried out by NGO's aimed at importing and encouraging the use of European dairy breeds in the 1980's. However, this increase is not fully reflected in the quoted figures as population has increased over this period from 10 to 14.7 million inhabitants. However, the

production is far from satisfying local demand for milk and milk products. Since the devaluation of the CFA Franc by 100% in 1994, the price of imported milk and milk products has more than doubled. Teuscher *et al*, (1992) estimated the level of imports of milk and milk products was 11480 tonnes, which represented about 50% of the adult per capita consumption. The low per capita consumption in subsequent years (less than half of Africa's) reflects the limits on imports of dairy products in the country, standing only at 23% of total per capita consumption. Consequently, local milk can compete with imported products. In the past, the availability of cheap products in international markets supported low consumer prices in the country. Approximately 50% of the population are urban dwellers. Figure 2.1. shows that although urban population is rapidly increasing, imports of milk have slowed down.



**Figure 2.1.** Dairy product imports relative to urban population (urban population relative to total population of the country)

This trend was confirmed by ILCA (1993). On the positive side, the present situation creates an extraordinary opportunity for dairy development. Already, many small peri-urban farmers are selling fresh milk at 200F perkg (0.3 \$US). This is the retail price recommended by Pingpoh (1985) who suggested that in order to make the dairy business profitable, the price of milk be increased by over 50%, from 140 CFA (1/5 \$US) to 214 CFA /kg. This reality has led some peri-urban farmers to use purebred Holstein Friesan cows. In order to maximize profit, these animals were imported for commercial production in increasing numbers over the last five years. For a sound and progressive development of the sector, dairy cooperative societies have been formed (e.g. the "Projet laitier" in Ngaoundéré, Adamaoua in the Northern part of the country and TADU dairy cooperative and Bamenda Dairy Cooperative Society in the North West). A private dairy processing company, SOTRAMILK, ensures the purchase of their liquid milk.

## **2.8. The urban demand for milk**

A study conducted by Vabi and Tambi (1995) revealed that urban dwellers had a high preference for fresh milk with a mean household consumption of 3kg for the high-income households, 3kg for the low-, and 2kg for the medium-income households. Although high-income households spent more money on fresh milk compared to the medium- and low-income households, the proportion of income spent on fresh milk was lowest for the high, followed by medium- and low-income households. The authors suggested the need to organize home-based education programmes on nutrition as a strategy for boosting the consumption of dairy products among low-income households. It is therefore surprising that Tambi (1998) classified milk and milk products in Cameroon as relative luxuries and



mentioned that they were considered as substitute for meat. Meanwhile low income households spent a high proportion of their money on these products.

## **2.9. Constraints to milk production in Cameroon**

Traditional dairy management, though sustainable for centuries, does not supply enough milk to meet the ever growing demand. Improvement in milk production in Cameroon is possible thanks to the introduction of European type dairy breeds. Though adapting to the environment, these exotic breeds and their crossbreeds are found to be susceptible to the challenging Cameroonian environment. Constraints to dairy production are listed in Table II.2.

**Table II.2.** Tabulated constraints to dairy cattle production in Cameroon

	<b>Constraints</b>	<b>Source</b>
<b>Nutrition</b>	1. Traditional grasses are of low nutritive value and demand adequate supplementation; in February, native <i>Sporobolus africanus</i> only contains 4.5% crude protein on a dry matter basis.	Njoya <i>et al</i> , 1999
	2. There is inadequate pasture management. Some areas are densely populated, leading to insufficient grazing land. Consequently many dairy farmers endeavour to cultivate grass.	
<b>Breeding and management</b>	1. Unavailability of good dairy breeds. Many people wish to get involved in dairy business but either they do not find dairy heifers for purchase or more often they are very expensive to be bought on cash. Some NGOs give loans to farmers in this line, to be paid in kind with a heifer or a bull of the same breeds 3 years later.	HPI, 1999
	2. There is a long calving to conception period with a mean of 185 plus or minus 105 days. Moreover, the calving interval is long meaning that there is a great need of increasing reproductive performance on farms.	Njoya <i>et al</i> , 1999
	3. In improved systems (semi intensive and intensive) there are problems with heat detection and low artificial insemination success rates.	

	<b>Table II.2.</b> Tabulated constraints to dairy cattle in Cameroon (continued)	
<b>Health</b>	1. Ticks and tick-borne diseases are an obstacle to the introduction of exotic dairy breeds. They show a high susceptibility to Babesiosis, cowdriosis and dermatophilosis. Attempts to control ticks with acaricides have been proposed.	Mbah, 1982 a,b Merlin <i>et al</i> , 1986 Merlin, 1987 Merlin <i>et al</i> , 1987 Bayemi 1991 Ndi <i>et al</i> , 1991 Douffissa 1993 Staschurski 1993 Ndi <i>et al</i> , 1998
	2. Brucellosis	Martrenchar <i>et al</i> , 1995
	3. Haemorrhagic septicaemia	Martrenchar and Njanpop 1994
	4. Gastrointestinal parasites: <i>Toxocara</i> , <i>Strongyloides</i> , <i>Coccidia Trichuris</i> , <i>Moniezia</i> , <i>Fasciola</i> and paramphistomes infest dairy cattle. Deworming with anthelmintic was recommended	Chollet <i>et al</i> , 1994
	5. Foot and mouth disease commonly present	Ekue <i>et al</i> , 1990 Bronsvort <i>et al</i> , 2002
	6. There are inadequate veterinary inputs by dairy farmers. Most of them keep their animals indoors, because of the fear of high tick load and worm loads. Exotic breeds though highly performing are very susceptible to parasites and heat stress. Therefore in Table II.1., they show very high mortality rates.	Mbanya <i>et al</i> , 1995
	7. Because of high costs of conventional veterinary medicine. Many farmers use ethno veterinary medicine	Nfi <i>et al</i> , 2001

	<b>Table II.2.</b> Tabulated constraints to dairy cattle in Cameroon (continued)	
<b>Processing</b>	1. Limited quantity of milk for processing and consumption in urban areas	HPI, 1999
<b>Marketing</b> <b>Consumption</b>	2. Farmers who are a long way from urban centres cannot easily sell their milk. Consequently, cows are milked once day to sustain the family needs. At farm level, there are no cooling or storage facilities for fresh milk as well as a lack of processing facilities and technical know-how. In peri urban areas there is no collection of evening milk for processing. Therefore, the milk is mainly consumed by family and fed to pet animals and calves.	HPI, 1999  Kameni <i>et al</i> , 1999

## 2.10. Milk processing

Traditionally, milking was found to be carried out once a day in the morning, mainly by women and children, often with very little hygiene and sanitation. The calf is allowed to suckle in order to induce milk let down in the zebu cows. The milk is low in microbial quality. Therefore it lasts for 3 to 4 hours at room temperature (ambient temperatures are 30 to 35 °C) in the northern part of the country. In the Western Highlands where temperatures are moderate (18 to 22 °C) the shelf life of milk is slightly longer. Traditional processing is carried out by women. Various locally made milk products can be seen in markets and shops in urban areas of Cameroon. Kameni *et al*, (1999) investigated milk products found in Cameroon and classified them as those from traditional or modern processing methods. Dairy plants make sweetened yoghurt, set yoghurt (natural), stirred fruit yoghurt, stirred plain yoghurt, and cheese. The following products are found at household level: Pandidam (fermented milk), Kindirmu (set yoghurt), heat treated milk, Lebol (butter), Nebam (butter oil) and sour milk.

Milk is pasteurized by processing plants - Sotramilk and Projet Laitier. Another dairy plant is being built at Tadu near Kumbo. These plants are not running at full capacity but ensure that seasonal volumes of surplus milk are efficiently utilized. Imele *et al* (1999) determined the composition of milk from White Fulani cows as: butter fat (3.89±0.17%), protein (3.52±0.21%), total solids (12.69±0.43%), solids-not-fat (8.79±0.44%). It might be better for the same work to be carried out with other breeds.

Kameni *et al* (2002) worked on suitable temperature and time for proper pasteurization of milk under local conditions in Cameroon. They recommended that at household level, milk should be heated to at least 74 degrees Celsius for more than 10 minutes to ensure safe milk supply in the country. Kamga *et al* (1999), attempted to determine the time of

maturation of cream for obtaining butter of higher quality and good yield. They suggested that cream should be matured for not more than 30 hours by farmers who have no refrigeration facilities (this period ensures better quality and yield of butter) and 7 hours by those who intend to use refrigerators. Lower temperatures led to earlier maturation of cream. A number of other studies dealt with cheese. Kameni *et al* (1994 and 1998) studied the production of cheese in Cameroon. Studies of Bafut cheese showed that a typical Bafut cheese is hard, cylindrical and of 2kg in weight and covered with a dry, hard rind formed by moisture loss during maturation. Furthermore, Kameni and Imele (1997) demonstrated that heat treating raw milk increased wet yield and recovery of total solids of local Edam-type cheese. Milk was heated to experimental temperatures up to 90 degrees Celsius and immediately cooled to 32 degrees Celsius. Milk gel setting time increased from 30mn to 165mn with corresponding experimental temperatures of 32 and 90 degrees Celsius respectively. These results imply the need to understand detailed local processing method for cheese making in order to give proper recommendations to farmers. If the milk is not heated, the resulting cheese might be high in microbial contents. In contrast if the milk is heated above 70 degrees Celsius, coagulation time might be too long.

Technologies for local milk processing at household level might be of great importance for remote areas where marketing of liquid milk is a problem. Milk can be transformed and the products transported to urban areas. However, stress should be put on hygiene for the products to be properly accepted.

## 2.11. Marketing of milk and meat

Milk marketing is primarily ensured by the informal sector. Middle men are rare as farmers directly take their milk to the market. Rather there are many small scale processing units which collect milk for processing into yoghurt and traditional sour milk.

In the dry season, market demand in Cameroon for milk products is very high but milk is scarce because cattle are managed in a transhumance system. Even when milk is available, the lack of refrigeration at farm level forces producers to make and market their products every day. The marketing system is mainly informal. In Garoua, there are large herds of cattle and a lot of milk in the rainy season. Women carry the milk products on their heads and walk around town to retail them. In Maroua where milk output is low, dairy products are expensive because of traditional form of management, and a special site has been provided for the sale of milk in the main market. In Bamenda, milk collection is done in main axes with refrigerated vans by Sotramilk. This is a dairy plant collecting in January 100 litres per day and in September-October (peak), 500 liters per day. They use blend and reconstituted milk to make their products (Mbanya *et al*, 1995). In order to ensure better marketing for their milk, farmers constitute themselves in cooperatives. Tambi and Vabi (1994), surveying one of the cooperative dairy farmers, said that the financial responsibility of the household head (gender), input cost, and price significantly influence market supply. They stated however that price is relatively inflexible to changes in market supply.

Meat consumption in Cameroon was of 217,000 metric tonnes (MT) in 1998 and 237 MT in 2003 (FAO, 2006). Ninety-eight percent of this was from domestic production while the remaining 2% was imported. Beef is the most important meat consumed, followed by mutton and goat meat, pork and poultry in that order. Other meats, including offals and game meat, are also important and account for one-fifth of total meat consumption. Total

meat consumption increased by 80% (4.4% per year) from 1980 to 1998. The largest absolute increase of more than 40,000MT was in beef consumption. Poultry meat consumption increased by more than three times while mutton and goat meat consumption more than doubled during the same time period. Fish is a relative necessity in Cameroon and is often substituted for beef and chicken by households whose profiles include being of low income levels, having large household sizes, are of middle age and are less educated. Whereas chicken and pork substitute each other, they are each complementary to beef. Profiles for households most likely to increase their purchases of chicken include being of high income levels and are public sector employed (Tambi, 2001). It is quite likely that the production of meat increases as the government of Cameroon has reduced the importation of frozen chicken by 5000 tons per annum with the possibility of definitely suspending importation if local producers can satisfy local demand (Fonzenyuy and Suika, 2005). This pushes prices up and encourages local production.

## **2.12. The way ahead**

Favourable factors for improved milk production were already outlined by Makek (1980). The Cameroon government has an ambitious plan to substantially improve livestock products by the year 2005 (MINEPIA, 2002). Moreover, the republic of Cameroon owns a large cattle population. Traditionally, livestock farming techniques have remained largely as they have been for centuries (Pradère, 1982). Although it seems difficult to bring about much improvement in the pastoral system, it is still necessary to assist these farmers particularly in the area of health control and milk hygiene, so that the products marketed will be safe for the public. Many regions still depend on them for the supply of milk. The Cameroonian climate is appropriate for good pasture development. Some areas,



especially in the Western Highlands, are free of tse tse fly and are therefore very suitable for dairy development. Although the performance of high producing breeds imported to Cameroon is lower than their genetic potential, it is still far above that of local breeds. These animals are therefore suitable for milk production in the country.

Enough work has already been done on crossbreeding local with exotic dairy breeds as cited in this thesis. These studies have recommended upon the use of F1 progeny. But because of the lack of a stabilised breed, there is a dependence on imported bulls or semen and artificial insemination. This leads to the lengthening of the calving interval in times of unavailability of imported semen and artificial insemination technicians. The dependence on imported semen has the advantage of farmers benefiting from genetic progress made in developed countries. However, as in the present situation, unplanned crossbreeding may lead to the disappearance of local breeds. Therefore, there is a need for research to tackle the preservation of local cattle genetic resources in the country, by characterising, selecting and breeding local purebreds for meat production in order to lead to dual purpose F1.

Little work has been done on nutrition using available local material. This is another area where research is needed, particularly in adapting research done in similar environments in other countries to Cameroonian conditions. The existence of dairy plants confirms the fact that there is a market for dairy products in the country. But the price paid to farmers for fresh milk could be better if farmers were efficiently organized in sound cooperatives instead of scattered small groups.

Much research is needed to study efficient methods of transferring research results to farmers. Some extension work on dairying has been accomplished by non-governmental

organizations which offer a credit scheme to farmers to own dairy cattle, but the number of in-calf heifers is still very limited. There is an urgent need for the government to assist dairy farmers in this line. In fact, there seems to be serious obstacles to dairy development unless the government organizes and supports the sector at least until the World Trade Organization convinces the European Union and the United States among other countries to completely stop subsidizing agriculture. Such a limited involvement of the state has helped small scale dairying to be successful in countries such as India. This partial support will help small farmers to develop production and be in the long term independent.

## 2.13. References

**Abassa, P. K., Mah, D. A., Zamba, P., Tawah, C. L., Messine, O., Oumate, H., 1993.** Factors affecting Gudali and Wakwa calf weights at birth and weaning on the Adamawa Plateau. *Tropical Animal Health and Production* 25:179-184.

**Atekwana, J. A., Maximuangu, J. C., 1981.** The performance of imported dairy cattle breeds in Cameroon. Paper presented at sixth meeting of the African scientific council, Libreville Gabon.

**Bayemi, P. H., 1991.** Seasonal dynamics of tick (Ixodoidea) infestation in commercially reared cattle in Yaoundé region, Cameroon. *Revue d'Elevage et de Médecine Vétérinaire des Pays Tropicaux*, Volume 44, Numéro 3, pp309-318

**Bayemi, P. H., 1999.** Study on the evolution of weight of cattle of Gudali breed in Bambui in the North West of Cameroon. *Bulletin of Animal Health and Production in Africa*, Volume 47, Number 1, pp33-39.

**Bronsvoort, B. M. de C., Nfon, C., Saidou H., Tanya, V., Kitching, R. P., Morgan, K. L., 2002.** Herd level risk factors for foot and mouth disease in the Adamawa Region of Cameroon. Edition Menzies F D, Reid S W J Dept Veterinary Clinical Sciences and Animal Husbandry, University of Liverpool, Leahurst, Neston, Wirral, CH64 7TE, UK pp212-220.

**Chollet, J. Y., Martrenchar, A., Bouchel, D., Njoya A., 1994.** Epidemiology of gastrointestinal parasitoses of young cattle in Northern Cameroon. *Revue d'Elevage et de Médecine Vétérinaire des Pays Tropicaux*, Volume 47, Numéro 4, pp365-374.

**de Leeuw, P. N., Dermott, M. C., Lebbie, S. H. B., 1995.** Monitoring of livestock health and production in sub-saharan Africa *Preventive Veterinary Medicine*, 25,195-212.

**Delgado, C., Rosegrant, M., Steinfeld, H., Ehui, S., Courbois, C., 1999.** Livestock to 2020: the next food revolution. Food, Agriculture, and the Environment Discussion Paper 28. International Food Policy Research Institute, Washington, USA.

**Douffissa, A., 1988.** Production et commercialisation du lait dans le Mbéré: Données complémentaires Contact, Volume 5.

**Douffissa, A., 1993.** Cattle production in the Mbere (Cameroon, Adamaoua) Collection études et thèses. Editions de l'ORSTOM, Paris, France 281pp.

**Ekue, N., Tanya, V. N., Ndi, C., 1990.** Foot-and-mouth disease in Cameroon Tropical Animal Health and Production, Volume 22, Number 1, pp34-36.

**FAO, 1970-1999.** Production yearbooks.

**FAO, 1970-1999.** Yearbooks of Trade

**FAO, 2000.** Production yearbook

**FAO, 2006.** FAOSTAT, <http://faostat.fao.org/site/339/default.aspx>

**Fonzenyuy, W. E, Suika, F. E, 2005.** Strategy for improving local poultry production in rural communities.

**Galvin, K., 1985.** Food procurement, Diet, Activities and Nutrition of Ngison Yoko, Turkana Pastoralists in an Ecological and Social context. PhD thesis Department of Anthropology SUNY, Binghamton, New York

**HPI, (Heifer Project International), 1999.** Evaluation of the dairy program of Heifer Project International (HPI) in Cameroon; Report Bamenda Cameroon

**IEMVT, 1975.** Growth and milk production of local and imported breeds , Bambui, Cameroon. France, Institut d'Elevage et de Médecine Vétérinaire des Pays Tropicaux: Report of activities. Rapport d'activité Année 1975 pp79-80.

**ILCA, 1993.** Market oriented small holder dairying ILCA (International Livestock Centre for Africa) newsletter, Volume 12, Number 1 pp1-3.

**ILRI, 1998.** Livestock, people and environment, ILRI (International livestock research institute), Working paper 2, Nairobi, Kenya.

**Imele, H., Kamga, P. B., Kamga, P., 1999.** Etude sur le lait des vaches White Fulani au Cameroun. Bulletin of Animal Health and Production in Africa, Volume 47, Number 4, pp151-153.

**IRZ, (Institute of Animal Research) 1982, 1983, 1984, 1985.** Annual Reports. Yaoundé, Cameroon.

**Kameni, A., Imele, H., 1997.** Effect of temperature on the recovery of milk solids in cheese Tropical Science, Volume 37, Number 3, pp129-133.

**Kameni, A., Imele, H., Formunyam, R., Djoko, D., 1998.** Evaluation of goat milk produced in the highlands of Cameroon for cheese making. Revue d'Elevage et de Médecine Vétérinaire des Pays Tropicaux, Volume 51, Numéro 3, pp259-263.

**Kameni, A., Imele H., Mbanya, N. J., 2002.** An alternative heat treatment for milk pasteurization in Cameroon. International Journal of Dairy Technology, Volume 55 (1), 40-43.

**Kameni, A., Mbanya, N. J., Nfi, A., Vabi, M., Yonkeu, S., Pingpoh, D., Moussa, C., 1999.** Some aspects of the peri-urban dairy system in Cameroon. International Journal of Dairy Technology, Volume 52, Number 2, pp 63-67.

**Kameni, A., Mbanya, J. N., Robinson, R. K., 1994.** Bafut: a Cameroon cheese. Dairy Industries International, Volume 59, Number 6, p27- 29.

**Kamga, P., Mbanya, J. N., Awah, N. R., Mbohhou, Y., Manjeli, Y., Nguemdjom, A., Pamela, B. K., Njwe, R. M., Bayemi, P. H., Ndi, C., Imele, H., Kameni, A., 2001.** Effect of the calving season and zootechnical parameters on milk yield in the western highlands of Cameroon. Revue d'Elevage et de Médecine Vétérinaire des Pays Tropicaux, Volume 54, Numéro 1, pp55-61.

**Kamga, P., Imele, H., Mendi, S., 1999.** Effect of temperature and maturation time of cream on the quality and yield of butter. Bulletin of Animal Health and Production in Africa, Volume 47, Number 4, pp167-172.

**Makek, M., 1980.** Production of fresh milk in Cameroon. Thesis, Ecole Inter Etats des Sciences et Médecine Vétérinaires, Dakar, 163pp.

**Martrenchar, A., Bouchel, D., Njanpop, B. M., Yaya, A., 1995.** Use of strain B19 in the prevention of bovine brucellosis in Northern Cameroon. Effect of dose on rate and duration of seroconversion in zebu females. *Revue d'Elevage et de Médecine Vétérinaire des Pays Tropicaux*, Volume 48, Numéro 1, pp37-40.

**Martrenchar, A., Njanpop, B. M., 1994.** First observation of an outbreak of haemorrhagic septicaemia due to *Pasteurella multocida* serotype B6 in Northern Cameroon. *Revue d'Elevage et de Médecine Vétérinaire des Pays Tropicaux*, Volume 47, Numéro 1, p19-20.

**Maule, J. P., 1990.** The cattle of the tropics. Centre for Tropical Veterinary Medicine. University of Edinburgh Redwood Press Limited, Melksham, Wilts Pp 101.

**Mbah, D. A., 1982a.** Mortality due to rickettsia, trypanosomiasis piroplasmiasis and streptothricosis among six genetic groups of cattle at Wakwa. *Science and Technology Review* 2: 81-88.

**Mbah, D. A., 1982b.** Adaptation of dairy cattle to Wakwa (Adamaoua) environment. I. Resistance to cattle ticks *Science and Technology Review, Agronomic and Animal Sciences Series* 2: 101-106.

**Mbah, D. A., 1984.** Adaptation of dairy cattle to Wakwa (Adamaoua) environment. II. Susceptibility to heat stress. *Science and Technology Review, Agronomic and Animal Sciences Series* 1: 125-132.

**Mbah, D. A., Mbanya, J., Messine, O., 1987.** Performance of Holsteins, Jerseys and their zebu crosses in Cameroon: preliminary results. *Science and Technology Review, Agronomic, and Animal Sciences Series* 3: 115-1126.

**Mbah, D. A., Tawah, L. C., Messine, O., 1991.** Performance of dairy cattle in Adamawa Cameroon. *Cattle Research Network Newsletter*, Number 3, pp10-12.

**Mbanya, J., Vabi, M., Nfi, A., Yonkeu, S., Kameni, A., Pingpoh, D., Moussa, C., 1995.** Report of survey on periurban dairy production in Garoua and Maroua IRZV (Institut de Recherche Zootechnique et Vétérinaire) Yaoundé Cameroon, December 1995

**Merlin, P., 1987.** Efficacy of chlorfenvinphos in the control of ticks on cattle in North-West Cameroon. *Revue d'Elevage et de Médecine Vétérinaire des Pays Tropicaux*, Volume 40, Numéro 1, pp77-81.

**Merlin, P., Tsangueu, P., Rousvoal, D., 1986.** Seasonal dynamics of the infestation of cattle by ticks (Ixodoidea) in the high plateaus of western Cameroon. I. A one year study of three sites around Bamenda. *Revue d'Elevage et de Médecine Vétérinaire des Pays Tropicaux*, Volume 39, Numéro 3-4, pp367-376.

**Merlin, P., Tsangueu, P., Rousvoal, D., 1987.** Seasonal dynamics of the infestation of cattle by ticks (Ixodoidea) on the Western high plateaus of Cameroon. II. Traditional extensive stockfarms. *Revue d'Elevage et de Médecine Vétérinaire des Pays Tropicaux*, Volume 40, Numéro 2, pp133-140.

**MINEPIA, 2002.** La stratégie sectorielle de l'élevage, des pêches et des industries animales. Ministère de l'élevage, des pêches et des industries animales, Yaoundé, Cameroun.

**MINPAT, 1986.** Sixth Five Year Development Plan, Republic of Cameroon, Yaoundé

**Ndi, C., Bayemi, P. H., Ekue, F. N., Tarounga, B., 1991.** Preliminary observations on ticks and tick-borne diseases in the North West Province of Cameroon. I. Babesiosis and anaplasmosis. *Revue d'Elevage et de Médecine Vétérinaire des Pays Tropicaux*, Volume 44, Numéro 3, pp263-265.

**Ndi, C., Bayemi, P. H., Nfi, A. N., Ekue, F. N., 1998.** Preliminary observations on ticks and tickborne diseases in the North West province of Cameroon. II. Bovine heartwater. *Revue d'Elevage et de Médecine Vétérinaire des Pays Tropicaux*, Volume 51, Numéro 1, pp25-28.

**Ndituru, C. G., 1993.** Remarks on donor support to animal production research Animal Production in Developing Countries. Occasional publication of the British Society of Animal production Number 16 pp5-11.

**Nfi, A. N., Mbanya, J. N., Ndi, C., Kameni, A., Vabi, M., Pingpoh, D., Yonkeu, S., Moussa, C., 2001.** Ethnoveterinary medicine in the Northern provinces of Cameroon. Veterinary Research Communications, 2001, Volume 25, Number 1, pp71- 76.

**Njoya, A., Mbanya, N. J., Nguemdjom, A., Kamga, P., Ndi, C., Kameni, A., Nfi, A., 1999.** Cattle productivity on smallholder farms in the western highlands of Cameroon. In Development of feed supplementation strategies for improving the productivity of dairy cattle on small holder farms in Africa. Proceedings of Research Coordination of a Coordinated Research Project organized by the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture held in Vienna, Austria, 7-11 September 1998.

**Njwe, R. M., 1984.** Provision of adequate animal protein to the Cameroon population by the year 2000AD: Problems and prospects Cameroon, Dschang University Centre, Cameroon.

**Pamo, E. T., Yonkeu, S., 1986.** A study of trends in some climatic parameters of the pastoral environment in Wakwa, Adamawa, Cameroon Revue Science et Technique, Series Sciences Zootechniques 2: 19-34.

**Phelan, J. A., 1994.** Experiences in Dairy development Commentary World Animal Review. Number 79.

<http://www.fao.org/ag/AGa/AGAP/WAR/warall/t3080b/t3080b01.htm#experiences%20in%20dairy%20development>

**Pingpoh, D. P., 1985.** Determination of the selling price of milk produced by the farmers of the Bamenda dairy cooperative society (BDCS). Revue Science et technique, Série Sciences Zootechniques, 1(4), pp.113 – 117.



**Piot, J., Rippstein, G., 1975.** Major herbaceous species of some rangelands in Adamawa, Cameroon Ecology and dynamic of different exploitation rates *Revue d'Elevage et de Médecine vétérinaire des Pays Tropicaux* 28:427-434.

**PNVRA (National Agricultural Extension and Research Programme), 2002.** Preparation of the farming season 2002 PNVRA in a flash, PNVRA/NAERP/NWP, Bamenda, Cameroon.

**Pradère, J. P., 1982.** Dairy production in the North West region of Cameroon *Dissertation Abstracts International, C, Volume 43, Number 2, p235.*

**Staschurski, F., 1993.** Variability of cattle infestation by *Amblyomma variegatum* and its possible utilisation for tick control *Revue d'Elevage et de Médecine Vétérinaire des Pays Tropicaux, Volume 46, Numéro 1/2, pp341-348.*

**Tambi, E.N., 1991.** Dairy production in Cameroon: growth, development, problems and solutions. *World Animal Review* Number 67, 38-48.

<http://www.fao.org/ag/aga/agap/war/warall/u1200b/u1200b0g.htm>

**Tambi, N.E., 1998.** Testing for habit formation in food commodity consumption patterns in Cameroon. *Journal of International Food & Agribusiness Marketing, Volume 10, Number 1, pp15-30.*

**Tambi, E.N., 2001.** Analysis of household attitudes toward the purchase of livestock products and fish in Cameroon. *Agricultural Economics* 26: 135–147.

**Tambi, N.E., Vabi, B.M., 1994.** Analysis of factors influencing dairy market involvement in Bamenda, North West Province, Cameroon. *Agribusiness (New York), 1994, Volume 10, Number 4, pp293-304.*

**Tawah, C. L, Mbah, D.A., 1989.** Cattle breed evaluation and improvement in Cameroon. A situation report Institute of Animal Research (IRZ), Wakwa, Ngaoundéré, Adamaoua, Cameroon.

**Tawah, C. L., Mbah, D. A., Enoh, M. B., Messine, O., 1999a.** Performance of taurine x Gudali zebu crosses subjected to artificial suckling in the tropical highlands of Cameroon Revue d'Elevage et de Médecine Vétérinaire des Pays Tropicaux, Volume 52, Numéro 1, pp65-70, 42.

**Tawah, C. L., Mbah, D. A., Messine, O., Enoh, M. B., 1998.** Effects of genotype and environment on milk production and reproduction of improved genotypes from the tropical highlands of Cameroon. Proceedings of the 6th World Congress on Genetics Applied to Livestock Production, Armidale, NSW, Australia, 11-16.

**Tawah, C. L., Mbah, D. A., Messine, O., Enoh, M. B., Tanya, V. N., 1999b.** Crossbreeding cattle for dairy production in the tropics: effects of genetic and environmental factors on the performance of improved genotypes on the Cameroon highlands. Animal Science, Volume 69, Number 1, pp59-68.

**Tawah, C. L., Rege, J, E. O., 1996.** White Fulani cattle of West and Central Africa. Animal Genetic Resources Information, Number 17, pp137-158.

**Tchoumboue, J., Jousset, M. N., 1982.** Acclimatisation trials using Brown Swiss dairy cows at the experimental farm of the National School of Agronomy in Nkolbisson. Science and Technology Review 2(2-3) 107-115.

**Teuscher, T., Bahm, A., Salah, J. N. S., 1992.** Livestock Research Development and Policy in Cameroon: analysis and reform proposals. Yaoundé, Cameroon: Institute of Agricultural Research for Development.

**Vabi, M. B., Tambi, E. N., 1995.** Household consumption patterns of dairy products in Bamenda urban town; Northwest Province, Cameroon. Journal of International Food and Agribusiness Marketing, Volume 7, Number 2, pp65-78.

**von Massow, V. H., 1984.** Dairy imports into sub-Saharan Africa: Development and policies International Livestock Centre for Africa (ILCA), Addis Ababa, Ethiopia pp1-2.

**von Massow, V. H., 1989.** Dairy imports into Sub-Saharan Africa: problems, policies and prospects Research report Number 17 ILCA, Addis Ababa, Ethiopia.

**Walshe, M. J., Grindle, J., Nell, A., Bachmann, M., 1991.** Dairy Development in Sub-Saharan Africa: A Study of Issues and Options Word Bank Technical Paper Number 135 Africa Technical Department series pp69.

**Wilson, R. T., Ehui, S., Mack, S. (editors), 1995.** Livestock Development Strategies for Low Income Countries. Proceedings of the Joint FAO/ILRI roundtable on Livestock Development Strategies for Low Income Countries, ILRI, Addis Ababa, Ethiopia, 27 February-02 March 1995 Food and Agriculture Organization/ International Livestock Research Institute, Nairobi, Kenya pp v.

**Winrock International, 1992.** Animal Agriculture in Sub-Saharan Africa, 162 pp, University of California, Davis, CA: Institute of Agricultural Development.