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Susmel P., Spanghero M., Mills C.R.

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Intensification of cattle milk production in mediterranean countries: low forage systems

P. SUSMEL
M. SPANGHERO
C. R. MILLS
ISTITUTO DI PRODUZIONE ANIMALE
UNIVERSITA DEGLI STUDI DI UDINE
(ITALY)

ABSTRACT - The development of intensive milk production from cows in mediterranean countries could improve the diversification of the agricultural economies and might usefully contribute to human dietary requirements. Nevertheless, complex problems prevent the complete exploitation of dairy production in these areas. Structural limits *affect the establishment of systems both before the production process (shortage of forage, capital, education, land tenure) and after (processing industry and markets). Only after these have been overcome by suitable political and financial interventions, can technical assistance be applied to the* functional limits *(genetic potential and management techniques) that directly affect milk production. An adequate genetic potencial can only be attained by combining the selective importation of suitable breeds, expanding the use of A. I. and adopting advanced selection techniques (e. g. MOET). The shortage of forage, characteristic of semi-arid zones, necessitates the use of high concentrate diets. Complete diets, adequately supplied with slowly fermentable carbohydrates and buffers, can limit unfavourable rumen fermentations and increase intake; diets with fat and a supply of cold drinking water can alleviate heat stress, whilst suitable mineral supplements must be used to balance losses in sweat.*

Key words: *Cattle, intensive milk production, structural and functional constraints.*

RESUME - «Intensification de la production de bovins laitiers dans les pays méditerranéens: systèmes pauvres en fourrage». Le développement d'une production laitière bovine intensive dans les pays méditerranéens augmente la diversification de l'economie agricole et peut contribuer efficacement à la couverture des besoins alimentaires des populations. Toutefois, des problèmes complexes empêchent l'exploitation totale du cheptel laitier dans ces zones. Des contraintes structurelles limitent la mise en place des systèmes à la fois en amont (disponibilité en fourrage, capital, formation, sol) et en aval (industrie de transformation et commercialisation). C'est seulement après que ces contraintes aient été levées par des actions politiques et financières adaptées que les techniques peuvent améliorer les facteurs fonctionels (potentiel génétique et techniques d'élevage) qui affectent directement la production laitière. Un potentiel génétique adapté ne peut être mis en place qu'en combinant l'importation sélective de souches adaptées à l'utilisation de l'insémination artificielle et la mise en place de techniques modernes de sélection (p. ex. MOET). La pénurie de fourrage, caractéristique des zones semi-arides nécessite l'emploi de rations riches en concentré. Des rations complètes judicieusement complémentées avec des glucides à fermentation lente et des substances tampons peuvent limiter les fermentations indésirables dans le rumen et accroîte l'ingestion; un régime enrichi en lipides et l'abreuvement à l'aide d'eau froide peut éviter les stress de chaleur, tandis qu'une complémentation minérale adaptée peut équilibrer les pertes de sudation.

Mots-clés: bovins, production laitière intensive, contraintes structurales et fonctionnelles.

Introduction

The problem of milk production in the mediterranean area can be examined in relation to its contribution to the human food supply and its role as an element of the agricultural economy.

The population of the countries in the mediterranean basin continues to increase: in the south and east mediterranean area, population growth rate often exceeds 3% per year (F.A.O., 1986b). The diets of these people are often poor in comparison with those of northern Europe and North America: energy intake is 10-20% lower, diets are largely based on vegetable products and the consumption of animal protein (27 g/day/head) is only half that recorded in Europe and little more than one third of North American intake (Table 1).

The development of milk production from cows in these countries would greatly help the supply of high nutritive value protein. Moreover, milk production, not only from cows, is biologically a more efficient process than raising and fattening animals and allows meat production as a by-product of the process (i. e. cull cows and calves). Furthermore, animal production systems based on ruminants are able to utilize feed resources which only partly compete with the human food supply.

From an economic and political point of view, countries with farming systems based solely on local products for

Table 1

FOOD SUPPLY (ENERGY AND PROTEIN) IN MEDITERRANEAN COUNTRIES. 1981-1983. (F. A. O. 1986a)

	Daily consumption per head			
	energy (kcal)	total	protein (g) vegetable	animal
Italy	3.542	105.6	51.1	54.5
Portugal	3.063	84.2	47.1	37.1
Spain	3.335	96.7	43.4	53.3
Yugoslavia	3.621	102.5	63.6	38.9
Greece	3.672	109.0	56.1	52.9
European countries	3.447	99.6	52.3	47.3
Turkey	3.150	84.7	64.5	19.8
Syria	3.103	85.4	60.7	24.7
Israel	3.062	103.1	49.0	54.1
Egypt	3.186	81.5	67.1	14.4
Libya	3.678	99.3	62.2	37.1
Tunisia	2.837	77.3	60.6	16.7
Algeria	2.663	69.7	53.1	16.7
Morocco	2.706	71.7	59.5	12.2
Malta	2.682	80.5	37.5	43.0
Non-european countries	3.007	83.7	57.1	26.5
Europe	3.427	98.7	42.5	56.2
U. S. A.	3.647	105.8	34.9	70.9

domestic consumption and without valuable natural resources (e. g. most of Mediterranean area), may be sensitive to some or all of the following external influences:

a) Periodic fluctuations in agricultural prices (approximately 20-30 % for wheat, coffee and rice and more than 30 % for sugar and cocoa (Maizels, 1984)).

b) Excessive dependence upon foreign countries for staple foodstuffs.

c) The conflicting demands in developing countries for industrialisation and services without a sufficiently well-integrated agricultural system. In fact only a well developed agriculture can free developing countries, without natural resources, from their commercial dependence on foreign manufacturers and staple foodstuffs. Only in this way is it possible to gain and maintain capital to invest in industrialisation and development.

It is unlikely that traditional farming methods will be capable of meeting the increasing demand for food and improve profit margins of farms; it is also difficult to envisage a general improvement in production across a whole country following strict, highly technical models. Instead, it will be necessary to use a different approach which allows the integration of *less intensive, traditional systems* based on sheep, goats and local breeds of cows which can be milked for the efficient exploitation of unfavourable areas, and *more intensive production systems* operating at a higher technical level only under more favourable or controlled conditions.

Local farms distributed across the countries already represent the extensive systems of dairy production in these areas, while an «appropriate intensification» has been severely prevented by the following main problems and constraints, connected with the physical environment and the socio-economical situation of these countries:

a) Limited availability of forage and water.

b) Low genetic potential of local breeds.

c) Poor education of farm workers.

d) Absence of capital for agricultural investments.

e) Absence of processing and marketing infrastructure.

It seems important to stress that dairy production in semi-arid countries differs from that of Europe due to the limited supply of pasture and other good quality forages.

The problems likely to be encountered during the establishment of fully integrated dairy economies in developing countries will be discussed, in terms of constraints and solutions, in the following pages.

Intensive milk production systems from cows

Intensive dairy cattle systems transform several inputs (feed resources, labour and capital investment) into milk that can either be sold fresh, conserved or transformed (into cheese, yoghurt, etc.) and this diversifies the markets and effects a complete integration within the food supply. Developing intensive dairy-cattle farming in unfavourable conditions, as found in mediterranean countries, is severely limited by numerous constraints that can be analysed systematically (see figure 1). It is possible to distinguish between the *structural limits* that affect the system before and after the production process and *functional limits* that specifically regard the performance of the animals (see figure 1.).

With regard to the first type of structural limit, the following should be considered:

a) The chronic shortage of forage due to the semi-arid climate and the orography of most mediterranean countries (Auriol, 1988).

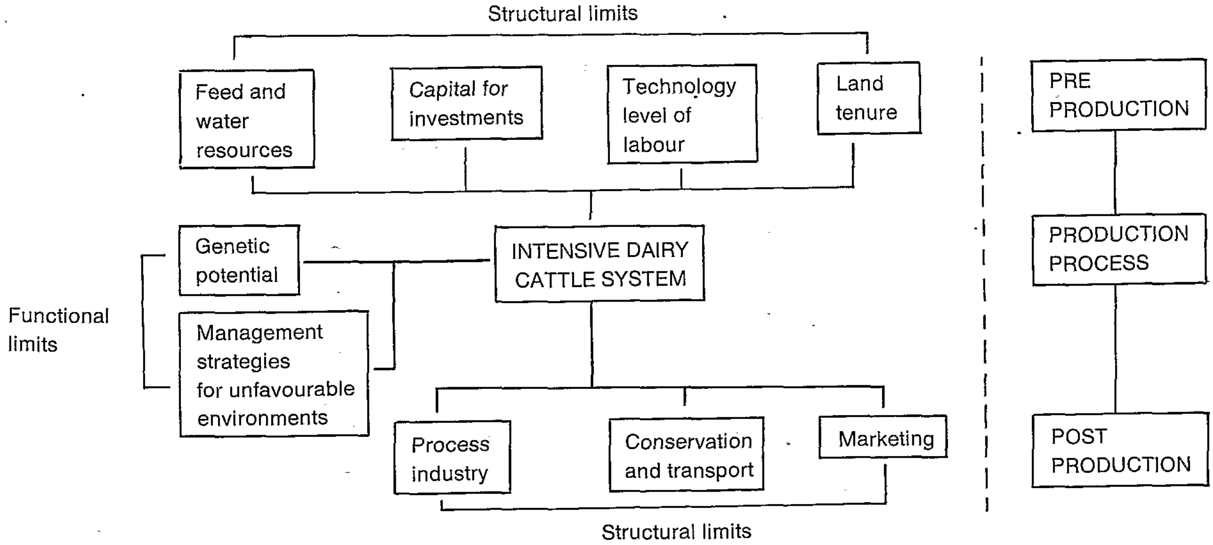
b) The lack of finance available for agricultural investment, especially in countries without natural resources.

c) The low level of technical education within the farming community.

d) The dissociation of land ownership and cattle farming that comes from a tradition of animal production based upon extensive grazing of common land.

Moreover, it should be remembered that, while the advanced production systems of North America and Western Europe can rely on close contact and integration with the food processing industry, the production potential

Fig. 1. Structural and functional limits in intensive dairy-cattle systems in mediterranean countries.



in unfavourable areas in often not completely exploited due to the structural difficulties of organizing a complete production cycle from the farm to the market (process industry, tansport, marketing, etc.).

These are the principal structural constraints which must be overcome before technical assistance can be effective. Nevertheless, considering the lack of technology, the absence of infrastructure and the severe environmental restrictions characteristic of these countries, it is difficult to envisage a general improvement in production across a whole country following strict, highly technical models. Less intensive production systems could be developed in small country villages to provide milk for local domestic consumption and contribute to a general agricultural improvement by:

a) Increasing specialization in livestock husbandry.

b) Reducing the use of cattle for traction.

c) Reducing the waste of feedstuffs by providing stores and barns.

At the same time, intensive systems would be established after suitable research (into availability of feed and water, good communications, suitably trained labour, size and location of urban centers, etc.) according to the following general guidelines:

a) Intensive dairy-cattle production centers should be located in suburban areas, closely connected with the food processing industry and the most important markets. These centers need to be established where there is enough agricultural land for adequate slurry disposal and yet be close enough to towns to make best use of any industrial feed by-products available.

b) The project would be developed according to local requirements, adopting suitable financial and political strategies (state farms, cooperatives, grant aided large private farms, etc.)

c) The low availability of forage would be compensated for by developing housed systems and feeding strategies based upon concentrates and by-products.

d) Agricultural colleges and training centres close to the existing farms should be created to improve the technical education of farm staff.

The dairy cattle population, or rather, their production characteristics, form the *functional elements* of the system and influence, to some degree, the level of inputs and outputs and, thus, the system efficiency. In this regard, it is necessary to have technical advice which considers not only production levels but also production efficiency, in terms of economics and profitability: this would avoid the simple transfer of inappropriate information, often obtained in different conditions, and will lead to pertinent solutions to specific problems. In general terms, two different types of advice can be employed simultaneously to exploit synergistic effects: improvement of genetic potential, and development of management techniques more responsive to the environmental conditions.

Genetic Aspects

A considerable fraction of the dairy cow population in the Mediterranean basin, particularly in North Africa and the Middle East, is represented by local breeds farmed for milk production, meat and traction, and having low levels of production (Table 2) (Mason, 1988).

Table 2

BREED DISTRIBUTION IN SOME MEDITERRANEAN COUNTRIES (MASON, 1988)

	Local	Breed type(%) cross-bred			Imported	Composition of imported breeds (%)
Italy	24		17		59	Fiesian 38, Brown 16 Simmental 5
Portugal	67		8		25	Friesian
Spain	27		25		48	Friesian 41, Brown 16
Yugoslavia		57			43	Simmental
Greece	17		70		13	Brown and Friesian
Turkey	90			11		Brown 7, Friesian 2, Jersey 2
Syria	95		3		2	Friesian
Israel	10				90	Friesian
Lebanon		63		37		Friesian
Egypt		99		1		Friesian
Tunisia	81		12		7	Friesian, Brown, Tarentaise
Malta	0		0		100	Friesian
Cyprus		64		36		Friesian

In fact, if one excludes the european mediterranean countries (Portugal, Spain, Italy, Yugoslavia and Greece), even if large variations exist between countries, the average production per cow (830 kg/year) is about five times less than the Western European average (Table 3) (F. A. O., 1986a).

The development of intensive dairy cow production systems cannot ignore the absence of sufficiently high genetic potential and performance characteristics. However, a selection programme based on the local population would be difficult to carry out and would give results, even if sophisticated techniques were employed, only in the long term. In the U. S. A., Canada and New Zealand, genetic improvement has increased yields between 38 and 53 kg/cow/year (Van Vleck, 1986). It is evident, therefore, that in areas characterized by difficult environmental conditions and the absence of structural and organizational elements for efficient selection programmes, the problem of low genetic potential can only begin to be resolved by importation. In this respect, as can be seen in Table 2, importation of selected dairy and dual-purpose breeds has already begun.

Extensive farming in the most marginal areas will necessarily continue to be based on local breeds with low productivity, but naturally selected for the difficult environmental conditions, and will eventually be improved by crossbreeding. In the intensive production systems, a more efficient programme of importation (bulls, semen, heifers, etc) could guarantee to raise genetic potential only if, at the same time, suitable housing is provided to protect dairy breeds sensitive to the harsh enviroment.

A basic problem is the choice of breed to introduce into production systems subject to difficult environmental conditions. In situations such as most of the Mediterranean countries where the maximization of outputs is often limited (by feed resources, technical and managerial ability, reduced intake capacity, etc) the objective is to obtain any given output at the lowest possible input. The use of breeds of lower production potential, such as dual-purpose, low live weight breeds found in the European Alps (Bavarian Simmental, Alpine Brown, Alpine Grey, etc.) could help to maintain high levels of productivity. In fact, if one assumes that there is no genetic difference in the efficiency of milk production and in maintenance requirements, it can be calculated that a dual purpose cow 150 kg ligther than average dairy breeds has a lower annual maintenance energy requirement (4,745 MJ) equivalent to the production of almost 1,000 kg of milk. Moreover, it is still capable of producing a calf of good beef conformation and a valuable cull cow carcass.

In addition, the introduction of specialized dairy breeds (e. g. Friesian/Holstein), selected for high milk yields in countries where forage supplies are adequate, into adverse environments is only possible where cow management is of a high standard. In fact, as demonstrated in Israel «average production per cow 8,200 kg. in 1985 (F. A. O., 1986a)», when structural and technical resources allowed, there was the possibility of using highly selected breeds (Holstein and Brown) to obtain similar production levels to North America and Western Europe; otherwise, as in most mediterranean countries, milk yields from these breeds falls to only 3,000 kg per lactation (Mostageer, 1988; Kayouli et al., 1988).

Table 3
COW NUMBERS AND MILK PRODUCTION IN MEDITERRANEAN COUNTRIES, 1985
(F. A. O., 1986a)

	Number of cows	Milk production	
	(n*10³)	per head (Kg*10²)	total (Kg*10⁶)
Italy	3,024	36.4	11,000
Portugal	328	22.6	740
Spain	1,900	34.1	6,500
Yugoslavia	2,700	17.0	4,595
Greece	360	18.8	678
European countries	8,312	28.3	23,513
Turkey	5,100	6.7	3,400
Syria	330	17.6	580
Israel	104	81.3	845
Lebanon	38	23.7	90
Egypt	1,430	6.7	960
Lybia	48	14.1	67
Tunisia	202	13.4	270
Algeria	682	8.9	610
Morocco	1,366	6.2	840
Malta	7	38.9	28
Cyprus	18	30.6	55
Non-european countries	9,325	8.3	7,745
Western-europe*	27,559	40.9	11,354

*Ireland, United Kingdom, Denmark, Belgium-lux., Netherlands, France, Germany and Italy.

For these reasons, imports into mediterranean countries, that in the past consisted mainly of the pure dairy breeds (as can be seen from Table 2), should now be directed towards dual purpose breeds where these problems are less evident.

Prior to any selection programme, an A. I. organization needs to be established: it is important to have well equiped Bull Centres and expert veterinary personnel for inseminations. If communications are difficult, it may be necessary to provide each large farm with its own bulls which can be used either for natural service or for semen collection and dilution for A. I.

In mediterranean countries it seems inappropriate to base selection and subsequent genetic improvement on progeny test programmes, due to the level of organization required, the cost, and the fact that results only become available in the medium to long term (Land, 1988). Results could be seen more quickly by combining imports of high quality semen with the selection of female lines using the techniques of multiple ovulation and embryo transfer (MOET): recent indications show (Woolliams and Smith, 1988) that MOET can be more than 50 % more efficient at selection than traditional methods of progeny testing. Even though MOET requires the use of high technology, if developed in nucleus schemes, it is adaptable to selection activities organized in single units which, in developing countries, can be located in large intensive farms.

Nutritional and managerial aspects

The attainment of sufficiently high levels of productivity within intensive dairy cow milk production systems is severely limited by the ability to establish and control feeding systems according to the environmental conditions (Fuquey, 1981; Balch, 1985; Berman, 1985; Beed and Collier, 1986; Chandler, 1987).

Considering the seasonality and chronic shortage of forage, it is generally necessary to use concentrate-based diets in zero-grazing systems. According to Economies (1987), in Israel the forage to concentrate ratio varies from 20:80 in early lactation, to 40:60 in mid lactation, whilst in Cyprus (Cyprus Agricultural Research Institute's Friesian herd) the proportion of forage varies from 25-30 % in early lactation, to 35 and 45 % respectively in mid and late lactation. The use of high concentrate diets is also necessary to prevent the usual reduction of forage intake seen in these hot climates. In fact, according to N. R. C. (1981), the reduction in intake due to temperatures above 25-27 °C, is much more severe when the forage:concentrate ratio is high. Although experimental results are lacking, it is likely, however, that the availability of small amounts of bulky fibrous feeds (low quality hay and crop residues) permits the use of larger amounts of concentrates than would be possible in feeding systems based on good quality forages and silage.

There are many references (see recent review of Smith, 1988) which show that the high use of concentrates has an unfavourable effect on rumen fermentation patterns, reducing milk-fat content and increasing body fat deposition (Table 4).

However, results obtained with yielding dual-purpose cows (Susmel et al., 1981) showed that a reduction in forage: concentrate ratio affected neither milk fat nor energy efficiency of milk production (table 5).

It is necessary to formulate optimum mixes concentrates along the following lines:

a) Avoid the use of rapidly fermentable starchy feeds (e. g. wheat and barley) in favour of less fermentable feeds (e. g. maize, sorghum and oats); moreover, it is helpful to use ingredients rich in cell wall content (e. g. beet pulp and soya skins) whose fermentation begins gradually only after a few hours (Doreau, 1988).

b) Formulate diets with reference to the Fibrosity Index («Chewability») which can be expressed as time spent chewing (ingestion plus rumination, min/kg/

Table 4.

EFFECT OF FORAGE: CONCENTRATE RATIO ON EFFICIENCY OF ENERGY UTILISATION FOR MILK PRODUCTION (SMITH, 1988)*

Forage: concentrate	60:40	40:60	20:80
Acetate:propionate	3.32	2.57	2.00
Milk fat ($g.kg^{-1}$)	35	30	27
M. E. intake ($MJ.day^{-1}$)	151.1	152.4	145.9
Body energy ($MJ.day^{-1}$)	-8.4	-2.3	7.3
Milk energy ($MJ.day^{-1}$)	58.3	55.1	43.6
Efficiency (%) **	38.6	36.2	29.9

*Adapted by Smith, 1988 from Tyrrel, 1980 and Flatt et al., 1969.

**Efficiency is milk energy as % of ME intake.

Table 5

EFFECT OF FORAGE: CONCENTRATE RATIO ON MILK PRODUCTION EFFICIENCY IN LOW YIELDING DUAL PURPOSE COWS (SUSMEL et al., 1981)

Forage: concentrate	62:38	53:47
ME intake ($MJ.day^{-1}$)	124.1	129.1
Body energy ($MJ.day^{-1}$)	0.1	0.9
Milk yield ($kg.day^{-1}$)	12.2	11.6
Milk fat ($g.kg^{-1}$)	3.64	3.73
Milk energy ($MJ.day^{-1}$)	32.1	31.7
Efficiency (%) *	26	25

*Efficiency is milk energy as % of ME intake.

d.m.) instead of the crude fibre content. It is positively correlated with saliva secretion which itself is important in contributing to rumen pH, maintaining a continuous turn-over of rumen liquid and for urea recycling (Sauvant and Doreau, 1988). Sudweeks et al. (1981) have suggested that the minimum Fibrosity Index for dairy cow diets is 31 min/kg d.m. and, therefore, in diets having a low forage:concentrate ratio (e.g.20:80) the concentrate should be formulated to have a high Fibrosity Index (> 10 min/kg d.m.). Table 6 shows some high fibrosity index ingredients (dehydrated lucerne, citrus pulp, etc.) suitable for inclusion in concentrates, whilst Table 7 shows how the physical form of ingredients either in short or long form, with fibrosity indices ranging from 4 to 10 min/kg d.m., influence mastication times.

Table 6

FIBROSITY INDEX OF SOME INGREDIENTS FOR CONCENTRATES (AFTER SUDWEEKS et al., 1981)

Ingredient	Fibrosity Index (min/kg d.m.)	Ingredient	Fibrosity Index (min/kg d.m.)
Dehydrated lucerne	37	Milled milo	11
Citrus pulp	31	Milled wheat	10
Cottonseed hulls	30	Bran	8
Milled rice hulls	16	Soya hulls	8
Pelleted corn cobs	15	Oil seed cakes	8
Milled barley	15	Milled corn	5
Pelleted compound feed	12	Molasses, urea	0
Milled oats	12		

Table 7

PRINCIPLES OF THE FIBROSITY INDEX (AFTER NORGAARD, 1983)

	Mean particle size (mm)	Fibrosity Index (min/kg/ d.m.)
Grain		
— finely milled	$\emptyset < 1$	4
— coarsely milled	$1 < \emptyset < 5$	10
Hay		
— finely chopped	$5 < \emptyset < 10$	.75*C. F.*
— coarsely chopped	$10 < \emptyset < 50$	2.25*C. F.*
— long forage	$\emptyset < 50$	3.00*C. F.*

*C. F.: crude fibre (% of d. m.)

c) Use suitable quantities of buffers. Experiments conducted in Florida (Schneider et al., 1984 and 1986), with dairy cows fed high concentrate diets showed positive effects on milk production when the rations had buffers added to compensate for the reduction in bicarbonate concentration in saliva and to prevent an excessive fall in rumen pH. In another experiment conducted in a hot climate using a high energy diet (Escobosa et al., 1984), the addition of sodium bicarbonate increased intake (+ 18 %), milk yield (+ 6 %), and fat content (+ 7 %).

d) Diets based on limited quantities of low quality forages need to be adequately supplemented with vitamins, especially vitamins A and beta-carotene, to maintain normal reproductive function.

The negative effects of using large amounts of concentrates in dairy cow diets can be reduced by adopting appropriate feeding systems, such as complete diets. Feeding diets in a mixed form increases the number of meals and allows a gradual consumption of concentrates: in this way, optimum rumen conditions are maintained (Kaufmann, 1976) and, especially with low forage to concentrate ratio diets, permits increased dry matter intake (Table 8).

In hot climates, biological efficiency in domestic animal production may be dependent upon the metabolic heat produced and, thus, the cost of its dissipation. Considering the theoretical values of the efficiencies of utilization of the principal nutrients for milk production (Table 9), it may be possible to increase biological efficiency by using glucose instead of propionate for lactose, and dietary fat instead of acetate for milk fat.

With the need to adopt high concentrate diets, the use of rations based on grain in forms resistant to rumen degradation (e.g. whole or cracked) rather than more fermentable forms (e.g. meal and flakes), allows a more favourable partition in the utilisation of the starch fractions in the diet. From an energy point of view, the utilization of end products of starch digestion which by-pass the rumen (glucose) is more efficient than the use of fermentation products (propionate). Moreover, the reduction of starch fermentation not only limits fermentation losses (methane and heat), but also permits a more efficient utilization of dietary fibre. Although no practical experimental data is available, work done at Beltsville (Moe et al., 1973) in a metabolism trial showed that the use of whole or cracked maize instead of meal for dairy cows, increased ADF digestibility by 25-30 %, and, more importantly, reduced metabolic heat production by 5-10 %.

Another way of reducing metabolic heat production would be to use dietary fats suitably treated to prevent a depression of rumen activity. The use of fat in the diets of animals subject to thermal stress has been ably demonstrated in pigs (Coffey, 1982) and in poultry (Dale and Fuller, 1980), whilst recent work with fattening lambs in Kuwait (Illian et al., 1988) showed increased liveweight gain and feed conversion efficiency. Similar results are not available for dairy cows, although work done in Arizona (Moody, 1962) showed lower body temperatures in animals fed diets with added cottonseed, while other authors (Chalupa, 1982; Kronfeld et al., 1980; Jenkins and Palmquist, 1984) reported increased efficiency of energy utilisation in diets where fat constituted up to 25 % of the metabolizable energy.

With regard to nitrogen nutrition, it is also necessary to maintain optimum conditions of biological efficiency. Nitrogen requirements need to be fully satisfied because an excess leads to an inefficient catabolism of aminoacids and the biologically expensive excretion of urea. Concentrate

Table 8.
MIXED DIETS FOR DAIRY COWS
(PHIPPS et al., 1984)

Concentrate: forage	.50		.65	
Ingredients	Separate	Mixed	Separate	Mixed
Milk yield (kg. day^{-1})	24.2	23.6	22.1	22.2
Fat (g. kg^{-1})	40.1	40.7	31.6	39.2
D.M. intake (kg. day^{-1})	16.1	16.4	14.3	16.5

Table 9

THEORETICAL PARTIAL
EFFICIENCIES OF SYNTHESIS OF MILK COMPONENTS
(SMITH, 1988)*

Precursor	Product	efficiency (%)
Aminoacids	protein	75-87
Glucose	lactose	95-96
Propionate	lactose	75-80
Acetate	milk fat	67-71**
Diet/body fat	milk fat	94-98**

* Range in theoretical efficiencies adapted from Baldwin et al. (1980) and Kronfeld (1976). ** Assuming propionate provides the glycerol for milk triacylglycerides.

mixes should be formulated to supply both degradable N and undegradable protein to balance poor protein quality forages. If large amounts of concentrates are to be used due to the absence of forage, sufficient readily fermentable energy may be available to allow the use of some easily soluble N sources (e.g. urea) without detrimental effects on animal health.

The loss of heat by evaporation is the most important physiological mechanism in protecting the organism from environmental temperatures (Chandler, 1987): in thermoneutral conditions, 50 to 70 % of waste heat is lost through non-evaporative processes (convection, radiation and conduction), while under conditions of thermal stress (> 30º C), evaporation represents more than 75 % of total heat loss (Table 10).

This results in a noticeable increase in water consumption for milk production, which, according to Winchester and Morris (1956), increases by approximately 50 % (from 2.5 to 3.8 kg. water / kg milk) as the ambient temperature increases from 15-20º C to more than 30º C. In semi-arid areas, the location of an intensive dairy farm is influenced by water availability, and in this respect, Wiersma et al. (1984) suggest installing piping capable of supplying at least 275 l/head/day.

In countries with hot climates, research has even been conducted to study the best way of preventing water heating and thus exploit its coolant properties: it has been estimated that 20 % of waste body heat (WBH) would be needed to warm cold drinking water (12-13º C) to body temperature, compared with only 8 % WBH to warm drinking water at 29-30º C (Table 11).

As can be seen from Table 12, experiments conducted under hot weather conditions showed that the water consumption of dairy cows declined as drinking water temperature decreased: nevertheless the cooling effect of the chilled water (i.e. 13º C) was greater than that of water of 24-28º C.

In a recent experiment in Texas (Wilks et al, 1988), the effect of offering dairy cows drinking water at either 10 or 30ºC was evaluated: chilled drinking water lowered respiration rate and body temperature, and increased feed intake and milk yield (Table 13).

In the absence of a piped supply, water may have to be extracted from underground wells. Although this water may be slightly saline, practical experiments conducted on very large dairy farms in Saudi Arabia (Challis et al., 1987) showed that high yielding cows (daily milk yield>25 kg) were able to tolerate water containing up to 0.44 % total dissolved solids (TDS). However, desalinating the water to 0.043 % TDS increased water consumption and feed intake, improving milk yield by nearly 7 kg per cow per day.

The increased loss of minerals in sweat needs to be

Table 10

PARTITION OF HEAT DISSIPATION BETWEEN EVAPORATIVE AND NON EVAPORATIVE COOLING AS INFLUENCED BY ENVIRONMENTAL TEMPERATURE (CHANDLER, 1987)

Temperature (ºC)	non-evaporative (%)	total (%)	evaporative surface (%)	respiratory (%)
0	78	22	14	8
10	72	28	18	10
20	58	42	30	12
30	25	75	57	18
39	3	97	77	22

Table 11

EFFECT OF WATER AT TWO TEMPERATURES ON THE AMOUNT OF HEAT REMOVED (CHANDLER, 1987).

Water temperature	Cooling effect * (Kcal/h)	(% of heat production) **
12.8º C	123	20
29.4º C	52	8

* Based on the heat used to warm 113.6 l of consumed water to body temperature. ** Based on heat production of 625 Kcal/h.

Table 12

EFFECT OF DRINKING WATER TEMPERATURE AND AMOUNT CONSUMED ON THE HEAT ABSORBED (LANHAM et al., 1986)

Experiment	Drinking water temperature (ºC)	Cooling value * (kacl/l)	Water consumed (l)	Heat absorbed (kcal)
1 st	7.2	31.8	20.7	659.3
	15.6	23.4	27.0	632.7
	23.9	15.1	31.4	473.8
2 nd	12.8	26.2	20.7	542.8
	26.7	12.3	28.5	350.2
3 rd	10.0	29.0	24.8	717.8
	16.0	23.0	27.4	631.2
	22.0	17.0	29.2	497.0
	28.0	11.0	31.0	341.3

* Estimated as kcal necessary to bring water to a body temperature of 39º C.

Table 13

RESPONSES OF COWS OFFERED DRINKING WATER AT EITHER 10 OR 30º C (WILKS et al., 1988)

	Drinking water temperature 10º C	30º C	Significance level
Respiration rate (breaths/minute)	70.5	81.0	—
Rectal temp. (º C)	39.7	39.9	$P < 0.0001$
Fat corrected milk (kg. day^{-1})	25.6	23.6	$P < 0.02$

balanced by increased intake to maintain homeostasis. Kronfeld (1979), suggested the use of acetogenic agents (ammonium chloride or sulphate) to re-equilibrate blood pH and to correct alkalosis, while Beed et al. (1984), considering the high potassium loss in sweat, confirmed the requirement for an adequate supplementation of this macronutrient in the diets of dairy cows under thermal stress.

Many studies (e.g. Badinga et al., 1984; Cavestany et al., 1984; Ron et al., 1984) have demonstrated impaired reproductive performance during the summer months in hot countries. In most mediterranean countries, characterized by a semi-arid climate, it may be necessary to resort to artificially controlling reproduction by synchronising oestrus cycles for insemination in spring (e.g. march-april). This would also confer a double advantage in that early lactation would occur during the first months of the year when there is generally a supply of good quality green forage, and during the hottest summer months the cows are in late lactation, with low nutrient requirements and hence less metabolic heat production.

Buildings should be designed and located to provide maximum animal comfort in combination with efficient day-to-day operation (Wiersma et al., 1984). In feedlot systems, protection from the full strength of the sun can be provided using simple overhead shades orientated north-south. In very hot climates, it may be necessary to provide additional cooling by water evaporation in buildings. Studies in Arizona (Wiersma, 1981) have shown substantially improved milk production and reproductive performance when cattle were provided with artificial cooling. A recent experiment conducted in Saudi Arabia (Armstrong et al, 1988), showed the beneficial effects of artificial cooling systems. Daytime temperatures reached 50ºC and milk production was significantly ($P < 0.01$) higher in both cooled groups (18.3 and 20.6 kg. d^{-1}) than the control (15.0 kg. d^{-1}) . Improved comfort can also be ensured for lactating cows by sprinkling them with water whilst they wait in the holding pen prior to milking. With regard to the positive effects of cooling on reproductive activity, an Israeli research group (Her et al., 1988) has recently shown that cows having spent a period with extra cooling (lasting 10 days starting 1 day before expected synchronized oestrus and continuing for 8 days after), exhibited oestrus behaviour more frequently than noncooled cows. The authors report, however, that fertility was not improved by cooling, probably due to the short duration of the test period.

Complete protection can be guaranteed in systems where the cows are housed and/or tethered. Housing also confers the following advantages to cow management:

a) easier oestrus detection, better conditions for insemination and a general improvement in reproductive management;

b) simpler and cheaper milking systems avoiding the need for milking parlours;

c) ability to group even small numbers of cows according to level of production.

The authors suggest that tethered systems should be used in preference on smaller farms to avoid investment in a milking parlour and other expensive equipment. Loose housed systems, such as feedlots, should only be used on large units where the expense of equipment will be a smaller fraction of the total investment.

Conclusions

The difficulties that must be overcome before establishing intensive dairy units developing mediterranean countries have been discussed. Two independent types of constraints have been identified: *structural limits* (shortage of forage, capital for agricultural investments, education, land tenure) and *functional limits* (genetic potential and management techniques). The former can only be overcome by political and economical strategies which must guarantee capital for investments, structural elements (communications, markets, processing industries) and technical education. The latter, comprising genetic and management aspects, are easier to solve using existing knowledge and can directly affect the production process in terms of biological and economic efficiency.

Before introducing intensive dairy farms into adverse conditions, it is important to consider systems developed in appropriate environments and not those from more favourable climatic areas, such as continental Europe. The following principle points should be considered:

a) the improvement of genetic potential with a programme of selective importation of dual purpose breeds, the expansion of A.I. and, subsequently, the introduction of advanced selection techniques

b) the adoption of nutritional strategies more responsive to environmental conditions and feed availability

c) the use of technical and managerial policies to improve housing and, hence, welfare conditions.

Thus, milk production can only usefully contribute to agricultural economies and food supplies in developing mediterranean countries if a combination of political, managerial and technical effort is applied to the structural and functional constraints surrounding the whole production process.

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