TYPOLOGY OF DAIRY FARMING SYSTEMS IN THE MEDITERRANEAN BASIN (CASE OF ALGERIA)

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Abstract: Characterization of breeding dairy cattle systems from the Mediterranean basin was conducted on 16 farms in the north center region of Algeria through a survey. Results are highly variable both structurally and in techno- economic management terms. The principal component analysis and clusters analysis have identified four groups of farms that differ in feeding strategies. The first group contains four farms that promote the use of forages (61.8% of the total dry matter (DM) intake). The costs are above the general averages (cost of production: 38.4 DA / liter ≈ 0.34 € and cost of food in total production costs = 71.8%). The average annual productivity is about 4328.6 kg. Five farms of group 2 are characterized by milk yields below average (4146.5 kg). The concentrates represent only 39.3% of total DM intake. The cost of production (37.1 DA ≈ 0.33 €/ liter of milk) and food costs are the lowest (65.17% of total production costs). The third group contains 5 farms dominated by profitable farms (4833.4 kg) and the lower cost of production (35.2 DA ≈ 0.31 €). A relatively high proportion of DM is provided by forages (53.6%). Food accounts for 69.2% of the total production cost. The fourth group consists of two farms whose main characteristic is the total absence of forage production. This is associated with a significant contribution of concentrates in the global feed balance (48.8% of total DM intake). These concentrated foods were poorly converted into milk as recorded yields are the lowest (3561.2 kg). Production costs are highest (45.1 DA ≈ 0.40 €) and relation price of food/total cost of production is very high (79.3%). So there are areas for improvement *via* land restructuring and the adoption of healthy feeding practices in order to ensure the profitability and sustainability of farms identified in this study.

Key words. Production system - food - milk yields - production costs - principal component analysis -clusters analysis.

Introduction

Milk is an important food in the Algerian consumer tradition, this is due to its nutritional value, its substitution with red and white meats relatively expensive and mainly related to the support of consumer prices by the State. At independence, the dairy sector, industrially almost nonexistent, based mainly on some craft workshops of milk derivatives production and dairy units in the center (Algiers), East (Constantine) and west (Oran) of the country. Dairy herd consisted of two local cattle breeds conducted in extensive conditions. These cows had been crossed with previously introduced breeds. The problem of food insecurity and its negative effects on the national economy forced the state as early as 1990 to reflect on a series of upgrade policies of the local milk production in order to promote self- sufficiency (*Belhadia et al.*, *2009*). Today, with a herd estimated at 1.9 million heads of cattle, including nearly one million dairy cows, domestic increasing demand for milk is not yet satisfied. The average consumption was estimated at 147 liters/capita/year in 2013, which ranks Algeria as a country of major consumption of milk when compared to Tunisia (83 liters), or Morocco (64 liters) (*Kacimi*, *2013)*. Our country imports milk powder to fill the gap, which costs approximately 769 million Dollars (M.A.D.R, 2013). These imports were a major constraint on the development of local production and collection of raw milk (*Srairi et al., 2013*). Efforts are being made by the government to encourage the development of this sector. Thus, national milk production was estimated at more than 3 billion liters during 2012/2013, an increase of 7.6% compared to the previous year. Dairy farming remains a kind of speculation that is difficult to manage given the diversity of parameters that are linked to it. Forage crops are far from meeting the food needs of the national herd in quantity and quality. In fact, the coverage rate is between 75 and 80% (M.A.R.D, 2012). To our knowledge, the Algerian bibliography is lacking data on the actual operation and the level of profitability of the dairy farms in a context of reduced public institutions of control and monitoring functions of the national herd performance. The purpose of this manuscript is to describe dairy cattle farms in the mid-northern region of Algeria through: (i) the characterization of the producers involved in milk production, (ii) analysis of different practices and strategies in place to manage the units surveyed and finally, (iii) identification of constraints and potentialities of current systems.

Materials and methods

Characteristics of the study area

It includes 5 regions, namely: Algiers, Blida, Boumerdes, Bouira and Tizi Ouzou. It covers an area of 1248400 ha or 0.52% of the total area of the country. In 2012, it accounted for around 11% of national milk production. The study area is

characterized by a temperate Mediterranean climate. Summers are hot and winters are rainy, sometimes snowy. The average annual rainfall is between 500 and 800 mm. Most rainfall is concentrated in the period from early October to late March. The temperatures are moderated by the maritime proximity and vary from 11°C in winter to 28°C in summer.

Data collection

The study was conducted by survey in 2013. Sixteen farms were selected to represent different conditions of milk production. The selection criteria are based on a minimum of 10 dairy cows per farm and the acceptability of the farmer to participate in this study. Data collected focused on the operator (age, education level and seniority in the practice of dairy cattle), the structural parameters of operations (agricultural land, cattle and equipment), management settings (feeding, production and reproduction of dairy cows) and economic burdens. The production cost of a liter of milk includes all food costs, labour, veterinarian care, artificial inseminations (if made) and even the litter and fuel. The estimation of rations was based on the quantities of food and concentrates in the ration distributed to the dairy cows. Nutrient intakes were determined according to data given by INRA (2007).

Statistical procedure

A descriptive analysis was performed for the evaluation of averages, standard deviations, minimum and maximum of the various parameters chosen. A typology of farms was established through the use of multivariate statistical analyzes: principal component analysis (PCA) and a cluster analysis. Statistical analyzes of data were performed using the Statistica 8.0 software (2008). For each farm, 10 variables were selected for characterization.

Results

Operators presentation

Through descriptive statistics performed on the data, it appears that 56% of farmers (n=9) were over 40 years of age. The level of education is considered low in 69% of cases since the farmers barely exceeded the primary level. Two farmers of our sample are private milk collectors. The number of years of service in the practice of dairy farming exceeds 10 years in 10 farms. Labour used is mostly typical employee in 62% of farms visited; it is used mainly in tasks related to breeding. Milking is done manually in farm due to the unavailability of a milking machine. The milk is kept in aluminum tanks for refrigeration in 12 farms, the rest uses buckets which they cool in a fridge.

Characteristics of farms studied

The parameters that characterize the surveyed barns are illustrated in table 1. The studied farms represent 138 ha of forage land. Significant differences are noted between the different parameters studied. Surveyed dairy farms are characterized by an average forage land of 8.6 ha per farm. Over 86% of farmers use their entire useful agricultural land for forage crops, mainly dry forages such as oats and barley and green fodder as clover, sorghum, corn and alfalfa. The study included a total of 365 heads of dairy cows with an average of 22.8 cows per farm and an average density of 2.7 cows/ha of forage. These farms showed a clear dominance of imported breeds (Holstein and Montbeliarde). The remainder (approximately 6% of cows) is genetic crossover. Stabling is hampered in all farms visited. The base feed consists essentially of oat hay and straw. Grazing is practiced on natural grass lands in order to enhance re – growth and in cereal fallow after the harvest. Silage is distributed in 3 farms only, mainly corn and sorghum silage. Concentrates are represented by industrial compound feed specially made for dairy cows. They are distributed in various quantities from a farm to another, from 5.5 to 10 kg per cow per day. These concentrates are 29 to 53% of total dry matter intake, with an average of 42.4 and between 0.34 and 0.56 Milk Forage Units (UFL) per kg of milk produced. The annual milk yields per cow in these farms fluctuate between 3053.4 and 6551.5 kg with an average of 4333.5 kg. The average production cost of a liter of milk in this study is 37.82 DA. The results showed that between 53.2 and 82.7% of the cost of production of one liter of raw milk was due to food. Artificial insemination was practiced in about 69% of farms and the average interval between two calvings is 452.1 ±31.7 days.

Table 1. Characteristics of farms surveyed (*n* =16).

Parameters	Minimum	Mean ± standard deviation	Maximum
Usefull Agricultural Land (ha)	0	9.3±7.7	27
Forage Land (ha)	0	8.6±8.1	27
Density: cow / ha of forage	-	2.7±1.8	6
Number of cows	10	22.8±19.2	78
Milk yield (Kg/cow/year)	3053.4	4333.5±961.3	6551.5
Energy from concentrates /kg of milk (UFL)	0.34	0.44 ±0.06	0.56
Share of concentrates in a total ration (% total dry matter intake)	29.2	42.4±5.9	53.25
Interval calving-calving (days)	407.2	452.1±31.7	505.7
Production cost of 1 liter of milk (DA)	30.4	37.8±5.1	45.2
Food costs/ total costs (%)	53.2	69.9±7.0	82.7

1 DA = 0.090 € (DA: Dinar Algérien, € Euro).

Typology of farms according to their characteristics

The survey identified four types of livestock from a principal component analysis performed on 10 structural and techno-economic variables. The first three factors in the analysis that explain 68% of total variability are taken into account. The first factor explains 30.3% of total variability, the second (22.8%) and the third (15.3%) as indicated in table 2. Only two correlations to the axis 3 were important for milk yield parameters (r =0.30) and the cost of food (r = -0.49) as <0.5.

Table 2. Results of principal component analysis (PCA) and axis of variation determined.

| Axis	Variables	Correlation of variable to axis	Total variability (%)	Cumulative variation (%)
Axis 1	- Useful Agricultural Land (SAU) - Forage Land (SF) - Number of cows (NVL)	0.76 0.87 0.75	30.3%	**30.3%**
Axis 2	- Energy from concentrates /cow / year) (ECVA) - Energy from concentrates / kg of milk (ECKL) - Share of concentrates in a total ration (PCRat)	-0.68 -0.63 -0.63	22.8%	**53.1%**
Axis 3	- Milk yield per cow per year (RLVA) - Interval calving-calving (IVV) - Production cost of a liter of milk (CPLL) - Food costs/ total costs (CA/CT)	0.30 0.51 -0.75 -0.49	15.3%	**68.4%**

The correlation between selected variables and the main factors (PF) indicates that the variables that strongly influence PF1, PF2 and PF3 are the areas and the number of dairy cows respectively: (PF1=structure parameters); the energy of concentrates/cow/year and per kg of milk produced and the proportion of concentrate in total dry matter intake (PF2=variables related to food strategy); calving interval, yields, cost of production and cost of food (PF3=variables related to management settings of reproduction, milk production and the production economics). However the correlation determined by the axes 1 and 2 between the master plan and the variables appears in graph 1.

Discussion

According to the results obtained for the farmers in the north-center region of Algeria, the collection means (cooling tank) exist among older farmers (r= 0.47), with lowest instruction level (r= -0.59) and oldest in the practice of dairy cattle (r=

0.25) with $p<0.05$. The concentrates in our study represent an average of 42.4 ± 5.9 % of total DM intake and 0.44 ± 0.06 UFL per kg of milk produced.
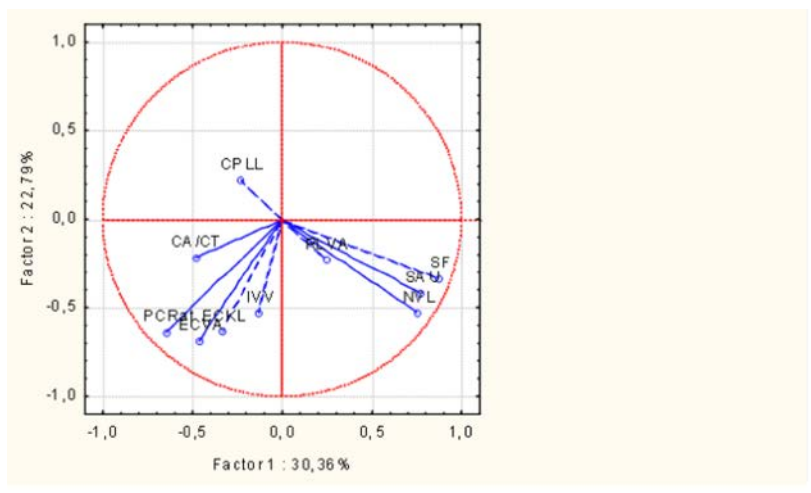
Graph1. Representation of structural and techno- economic variables of dairy farms on axes 1 and 2 determined by the Principal Component Analysis.

Four groups of farms were selected (graph 2) following the cluster analysis.
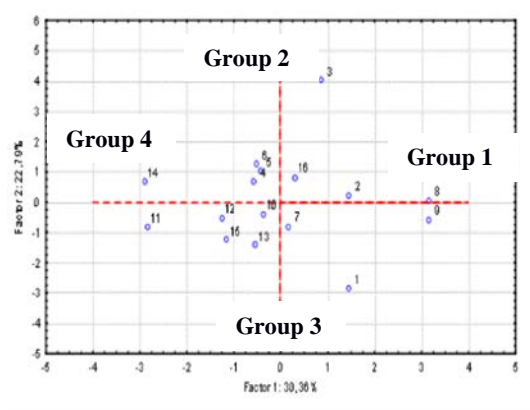
Graph 2. Graphical representation of farmers groups (determined by the axes 1 and 2).

In a previous study of *Madani et al.* (2004) in semi-arid region of Algeria, similar intervals to ours were highlighted. The amount of concentrates represent between 42 and 53% of DM intake and between 0.32 and 0.53 UFL per kg of milk. While varying mean values between 40.9 and 70.5% of the total DM with an

average of 56 ±7.42% were reported by *Ghozlane et al.* (2009) in the farms of Eastern Algeria (Constantine). The result was higher (73.1%) in intensive farms in Morocco (*Srairi and Kessab*, 1998). While in France, on the tropical island of Réunion, where breeders lack of fodder, there they are forced to distribute significant amounts of concentrate which represent on average 55% of the dry matter intake (Bony *et al.*, 2005). A significant change in milk yields is observed in 7 farms (CV>20%). This variability between farms and within the same farm is mainly related to the animal itself (race, stage of lactation, lactation rank and different lactation lengths) (*Millogo et al.*, 2008). A higher average milk yield (4884 kg) was found in the farms in the region of Médéa in Algeria (*Kaouche et al*, 2012). The production cost of a liter of milk was exceeding the sale price to dairies at 11 breeders. This selling price was set in 2012 at 34 DA a liter of milk grading 34 g of fat. Note that the difference between the sale price and the production cost is compensated by the help of the State estimated at 12 DA for each liter of milk produced by the farmer and 1 DA additional for each gram of fat beyond 34 g/liter.

These high production prices observed mainly on farms where the concentrate was used at a rate higher than 53% of total dry matter intake by cows. The results showed that nearly 70% of the cost of production of one liter of raw milk is allocated to food. *Ghozlane et al.* (2009) reported even a higher ratio (80%). The interval between two calvings was variable in the present study from one farm to another and within the same farm. Indeed, the difference introduce wide variations (CV =23%) in a single production unit. It exceeds the economic targets for 12 months on all farms visited. One of the factors commonly put forward to explain these delays is the conduct of reproduction with a lengthening of the interval between calving and fertilizing insemination. However, lengthening interval between two calvings from 4 to 6 months compared to the standards with an average of 420 days in nearly 83% of farms was also noted by *Kaouche et al.* (2012). The control of reproduction is a determining factor in the economy of a farm. Indeed, the presence of animals that do not reproduce increases expenses for the farmer and prevent the renewal of the herd. Improvements in farming practices, including food, have a positive effect on calving intervals (*Compère and Dupont*, 2005). Of all the variables studied, the cow's number in our study sample appears to be strongly associated (R^2= 0.60) to the size of the forage land ($p<0.01$) but weakly correlated (R^2=0.03) to milk yield. This is related to poor livestock management. However, energies ECVA and ECKL were determined to be correlated with PCRat, with respectively (R^2= 0.56), $p<0.01$ and (R^2= 0.30) with $p<0.05$.This demonstrates the high share of energy from concentrates in the total energy balance. The various parameters characterizing the 4 groups of farms identified from the cluster analysis are shown in table 3.

Table 3. Characteristics of the groups of farms identified.

Groups of farms Numbers	Group 1 (*n*=4)	Group 2 (*n*=5)	Group 3 (*n*=5)	Group 4 (*n*=2)
Useful Agricultural Area (ha)	21	3.8	7.2	5
Forage Area (ha)	21	3.6	7.2	0
Number of dairy cows	47	12.6	18.8	10
Milk Yield per cow per year (kg)	4328.6	4146.5	4833.4	3561.2
Energy from concentrates/kg of milk produced (UFL)	0.43	0.41	0.49	0.45
Share of concentrate in total ration (% DMI)	38.2	39.3	46.4	48.8
Production Cost of 1 liter of milk (DA)	38.4	37.1	35.2	45.1
Food cost/total cost (%)	71.8	65.1	69.2	79.3

DMI : Dry Matter Intake.

The first typology group "large farms tend to forage", contains four farms with useful agricultural land completely used for forage crops (21 ha). This means that this group of farmers promotes the exploitation of fodder compared to concentrate in the energy balance of the cows (the largest share of fodder compared to other groups and compared to the average: 61.8% of total dry matter). However, the economic burdens remain negative and higher than the overall averages (production cost=38.4 DA and food cost=71.83% of the total cost). This may be due to management difficulty of the important number of cows in this group (*n* = 47). Indeed, these large herds require much more food, labour and care, which increases farmers spending. The average annual productivity is high, on the order of 4328.6 kg, it is almost equal to the average (4333.5 kg). This is a group of breeders that characterizes the beginning of specialization in the field of bovine milk production. The five farms in group 2, "Small farms with limited resources", are characterized by milk yields below average (4146.5 kg). Concentrates represent only 39.3% of DMI. Indeed, this group of breeders records low and below average rates production costs (37.1 DA/liter of milk) and minimum food expenses (65.2%). But, he holds an effective reduced cattle (12.6 heads) and low forage area (3.6 ha), this type of farmers suffer from a lack of financial means to supply concentrates to improve yields. The third group "specialized farms", with 5 farms, dominated by profitable units with the highest average yield (4833.4 kg) and the lowest cost of production (35.2 DA/liter). A relatively high proportion of dry matter intake is provided by concentrates used intensively (46.4%) but effectively valued. This means that a good feed management is practiced in these farms to cover the needs of the animals. This is the group of farms considered as leaders in milk production. The cost of food is fairly low compared to other groups and slightly below average (69.2%). In contrast, it was the 4th group containing 2 farms, "Without land holdings", whose main characteristics are the complete lack of forage production and a herd size of 10 cows on each farm. This is associated with significant concentrates contribution in the global energy balance (48.8% of DMI).

These concentrates were poorly converted into milk as yields were recorded as the lowest (3561.2 kg). This use of the massive purchase of food (forage and concentrates) have added to the costs of these operators, production cost of a liter of milk highest (45.1 DA) and a very important food prices (79.3% of total). This category typically represents smallholder's dairy farms. The results of this study confirm the importance of the effect of diet on the diversity of farming systems in the study area. This is consistent with results of the literature (*Srairi and Lyoubi, 2003; Millogo et al., 2008; Gabbi et al., 2013*). The indicators that define axis 2 (food strategies) and axis 3 (parameters related to production economics), coincide with those found in Morocco (*Srairi and Lyoubi*, 2003), while the food management in the study of *Gabbi et al. (2013)* have a correlation with axis 1.

Conclusion

The analyses of all structural and techno-economic characteristics of surveyed farms shows that there is not in our sample an ideal type of farming that would bring together the contributions reasoned forage/concentrate in total DMI (group 2) so that the animals can reach their maximum production potential (group3), an optimal amount of energy from concentrates annually (groups 1 and 3), minimum cost of producing a liter of milk (group 3) with the least food expenses (group 2). In general, groups 1, 2 and 3 totaling 14 of the 16 farmers surveyed, all show higher milk yields than 4000 kg, despite the different dry matter provided by fodder from one group to another (61.8, 60.7 and 53.6%). On the other hand, one group with 2 units suffers from low yields (3157.3 kg), may be due to the excessive use of concentrates that are not valued in their entirety, associated with massive purchases of fodder that are poorly exploited in the absence of rationing and food formulations, which led to heavy spending. Fodder in this study can barely meet the maintenance needs of the animals as on average 0.44 UFL are provided by concentrates for the production of one kg of milk. The performance of animals also are low, although 94% of the cows are imported and therefore of high genetic merit. However, the constraints related to breeding are numerous and their exercise will require an arsenal of human and financial resources. These constraints include in the first place a food factor which represents the major handicap of the entire dairy production industry. So there are areas for improvement through the restructuring of land in order to size the farms with sufficient forage area, recovery of pastures, modification of harvesting techniques and conservation of forages (haymaking, especially silage) in order to compensate for off peak periods and the spreading of good feeding practices (food rationing and formulations) in order to ensure the profitability and sustainability of farms identified in this study.

Acknowledgment

Tipologija sistema u proizvodnji mleka u mediteranskom basenu

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Rezime

Karakterizacija sistema uzgoja muznih krava iz mediteranskog basena je sprovedeno na 16 farmi u severnom centru regiona Alžira. Rezultati su veoma varijabilni i strukturno i tehnološki u smislu ekonomskog upravljanja. Analiza PCA i klastera je identifikovala četiri grupe farmi koje se razlikuju u strategijama ishrane. Prva grupa sadrži četiri farme koje promovišu korišćenje kabaste hrane (61,8% od ukupnog unosa suve materije). Troškovi su iznad opštih proseka (troškovi proizvodnje: 38.4 DA/litar ≈ 0.34 € i troškovi hrane u ukupnim troškovima = 71,8%). Prosečna godišnja produktivnost je oko 4328,6 kg. Pet farmi grupe 2 odlikuju prinos mleka ispod proseka (4146.5 kg). Koncentrati predstavljaju samo 39,3% od ukupnog unosa SM. Cena proizvodnje (37,1 DA ≈ 0,33 € / litar mleka) i troškovi hrane su najniže (65,17% od ukupnog broja). Treća grupa sadrži 5 farmi gde dominiraju profitabilne farme (4833,4 kg) i niži troškovi proizvodnje (35.2 DA ≈ 0.31 €). Relativno visok procenat SM obezbeđuje se iz kabaste hrane (53,6%). Hrana čini 69,2% od ukupnih troškova proizvodnje. Četvrta grupa se sastoji od dve farme čija je glavna karakteristika potpuno odsustvo krmne proizvodnje. Ovo je povezano sa značajnim doprinosom koncentrata u globalnoj ravnoteži hrane (48,8% ukupnog suvog unosa materije). Ova koncentrovana hraniva se loše konvertuju u mleko, što pokazuju mali prinosi (3561,2 kg). Troškovi proizvodnje su najviši (45,1 DA ≈ 0,40 €) i veoma visok odnos cena hrane/ukupnih troškovi proizvodnje (79,3%). Dakle, postoje oblasti za unapređenje putem restrukturiranja zemljišta i usvajanje zdravih praksi ishrane kako bi se osigurala održivost i profitabilnost farmi identifikovanih u ovoj studiji.

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