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Some strategies proposed in three Mediterranean countries to develop dairy sector

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Abstract. The present paper presents the different strategies followed in three Mediterranean countries (Algeria, Greece and Egypt) to develop dairy sector, namely characterization of dairy farms and assessment of milk quality and safety. The research activities were conducted on dairy cattle sector in Algeria, Northern Greece and Egypt, while sheep-goat sector was studied in Northwest Greece. Farmers were interviewed about some hygiene practices, animal health, involvement of woman and traditional dairy products produced on the farms. Raw milk samples were also collected and analyzed for basic physicochemical and microbiological variables. Results revealed that Greek farmers respect hygienic practices better than Algerians and Egyptians; therefore, mastitis is not the most observed disease in the Greek farms compared to Algerian and Egyptian farms. Few women were involved in the work at farms. In the three countries, many traditional dairy products were produced on the farms for their own consumption, except for dairy cow farmers in Greece who prefer to sell all the milk. Sheep-goat milk quality is good, likewise cow milk physicochemical parameters collected in all the three countries were within the recommended values, but they cannot satisfy the high protein and fat contents demanded by the processors. It is necessary to provide guidelines of good practices for Algerian and Egyptian farmers to limit the mastitis in the farms. Also, new technologies should be introduced in Mediterranean countries to improve milk quantity and quality.

Keywords. Mediterranean countries – Milk quality – Safety – Hygiene practices.

Rapport sur les stratégies suivies dans les pays méditerranéens pour développer le secteur laitier

Résumé. Le présent rapport présente les différentes stratégies suivies dans trois pays méditerranéens (Algérie, Grèce et Égypte) pour développer le secteur laitier, à savoir la caractérisation des exploitations laitières et l'évaluation de la qualité et de la sécurité du lait. Les activités de recherche ont été menées sur le secteur des bovins laitiers en Algérie, dans le nord de la Grèce et en Égypte, tandis que le secteur ovin-caprin a été étudié au nord-ouest de la Grèce. Les fermiers ont été interrogés sur certaines pratiques d'hygiène, la santé animale, l'implication de la femme et les produits laitiers traditionnels produits dans les fermes. De plus, des échantillons de lait cru ont été collectés et analysés pour des variables physico-chimiques et microbiologiques basiques. Les résultats ont révélé que les fermiers Grecs respectent mieux les pratiques d'hygiène que les Algériens et les Égyptiens ; par conséquent, les mammites sont moins fréquentes dans les fermes Grecques comparativement aux fermes de l'Algérie et de l'Égypte. Peu de femmes étaient impliquées dans le travail de la ferme. Dans les trois pays, de nombreux produits laitiers traditionnels étaient produits dans les fermes pour leur propre consommation, à l'exception des éleveurs de vaches laitières en Grèce qui préfèrent vendre tout leur lait. La qualité du lait de brebis et de chèvre est bonne, de même que les paramètres physico-chimiques du lait de vache collectés dans les trois pays qui se situaient dans les valeurs recommandées ; mais le lait ne

satisfait pas les demandes des transformateurs en termes de teneurs en protéine et en matières grasses. Il est nécessaire de fournir un guide de bonnes pratiques aux éleveurs Algériens et Égyptiens pour limiter les mammites dans les exploitations. Aussi, les nouvelles technologies devraient être introduites dans les pays méditerranéens pour améliorer la quantité et la qualité du lait.

Mots-clés. Pays Méditerranéens – Qualité de lait – Sanitaire – Pratiques d'hygiène.

I – Introduction

Growth in world milk production is projected to increase by 22% by 2027. Dairy demand in developed countries has been shifting for several years towards butter and dairy fat (OECD and FAO, 2018). The dairy sector is still among the most fundamentally sector in Mediterranean countries as it participates to promote food security, stimulate rural economic development and ensure employment through the whole dairy chain in the region. In Greece, the dairy industry is one of the most important and developed industries. It represents about 7% of the total food industry (winery, brewery, etc) with about 32% of the food industry turnover (Chasapis and Christodoulaki, 2007-2010). However, milk and dairy products are among the main ingredients imported for processing (Faniadis, 2020). Algeria was the third largest dairy importing country in 2018 after China and Mexico despite the government aims to reduce dairy imports; milk drinks made from reconstituted milk powders dominate the country's dairy consumption, making Algeria a significant market for whole milk powder and skim milk powder (Hoogwegt Group, 2018). Likewise, in Egypt, domestic production meets only 72 % of Egypt's demand. In order to fill the gap between the demand and supply of good quality milk, dairy processors and retail channels tend to rely on imports of milk powder and other dairy products (ILO, 2020). Also, it is one among the main importers of butter and it is expected to more than double their imports of cheese by 2027 (OECD and FAO, 2018).

In fact, high milk quality production encourages the dairy industries to produce a wide variety of dairy products. It seems that dairy consumption is associated with a decreased prevalence of metabolic related disorders (McGregor and Poppitt, 2013). However, Algeria, Greece and Egypt are facing many challenges to produce more milk with better quality and safety in the future to meet the demand of dairy processors and ensure food security. In addition, it is important that developing countries invest in the new technologies to set up a strong plan to improve dairy genetic instead of continuing to import dairy cows and powdered milk and dairy products to cover its needs.

Despite the importance to improve the whole dairy chain in Mediterranean countries, a lack of clear information on dairy farmers, collectors and processors, milk quality and safety, and sales and commerce in the region, mainly in North Africa, limits the stakeholders and decissors ability to make changes in the sector.

However, for identifying the different gaps that constraint dairy chain in Mediterranean countries and in order to suggest interventions to overcome these barriers and implement new ideas, many actions were conducted and ongoing under the ERA-NET ARIMNet2-2017 Project "Characterization of Dairy Chain in Mediterranean Countries and Adoption of Optimum Technologies to Improve Dairy Value Chain". The consortium of the present project is composed of 4 partners (Algeria, France, Egypt and Greece), and one collaborator (Spain). The work plan of the project is divided into 3 work packages (WPs), WP1: Analysis of dairy chain in Mediterranean countries, WP2: Assessment of milk and dairy products quality and safety along dairy chain and WP3: Introducing and testing new technologies in North Africa to improve milk quality and preservation. This article deals with the work carried out on dairy cattle in Algeria and Egypt, and on dairy cattle, sheep and goat in Greece. Our activities aim to suggest strategies to characterize firstly the dairy farms and secondly to evaluate the quality and safety of raw milk to develop the dairy sector in three Mediterranean countries, Algeria, Greece and Egypt.

II – Material and methods

1. Areas of study

The present studies were carried in Algeria, Greece and Egypt.

In Algeria, the research activities were held on dairy cow farms in the wilaya of Setif (North East, Algeria); Setif is a semi-arid region, characterized by a subtropical climate with hot summers and cold to mild winters where the breeders prefer to raise Montbeliarde and Fleckvieh cows than the Holstein breed because of their adaptability to the difficult conditions of the region. The wilaya of Setif is a major dairy basin with an annual milk production of around 300 million liters of milk, which corresponds to 11.5% of national production, so it is the first milk producer Wilaya in Algeria (Dechambre, 2018).

In Greece, research activities were conducted in 2 regions, in the regional unit of Ioannina (Epirus, Northwest part of Greece) on dairy sheep and goat farms and in central Macedonia (Northern Greece) on dairy cow farms.

In the region of Ioannina, the local goat breed (Greek Goat) (*Capra prisca*) consists the major part of the population with good adaptation to the environmental conditions. Also mixed breeds existed in the majority of sheep farms. Although there were some farms with purebred animals of the local sheep breeds of Katsika (Karamaniko) and Kalaritiko. In central Macedonia, the most common breed of dairy cows raised is Holstein. In 2020, the annual milk production in central Macedonia represents more than half (51.59%) of the national production of cow's milk in Greece (ELGO-Dimitra, 2021).

In Egypt, the research activities were conducted in 11 dairy farms, 8 small farms located in Behara and 3 commercial farms located on Behara, Faum and Sharkia governorates. Milk samples were collected from Giza, Benisuef and Alexandria governorates.

2. Questionnaires survey

For analyzing the dairy chain in Algeria, Greece and Egypt, many questionnaires have been designed to collect information from farmers (feed management, animal health, practices handled for milking and storage), milk collectors (milk quantities collected, tools used to assess milk quality, milk storage condition and transport, cleaning and disinfection of tanks and all dairy equipment) and dairy processors (milk handling and selling practices dairy products produced such as milk, cheeses or other products using milk).

Data were obtained through interviews of individual farmers by visiting 50 farms in Algeria, 40 in Northern Greece and 11 in Egypt. In the sheep and goat survey, 52 farms participated as described by Pappa *et al.* (2021).

In the present paper, only the aspects mentioned below are reporting. However, the present article focuses in providing an overview on the characteristics and management of visited dairy farms in the three countries are presented, while the other data gathered are still being analyzed. Dairy cattle farms were categorized in Algeria and Egypt as small (<10 cows), medium (10-20 cows) or large scale (20 cows); while in Greece, dairy cattle farms could be small (<50 cows), medium (50-100 cows) and large scale (>100 cows). Disease and animal health problems that concern dairy farms as mastitis, low fertility or others (lameness cow, digestion...) in each country were assessed; hand washing by farmers before milking were noted by Yes /No. Change of the litter observed in the farms is classified into 3 categories: frequent/ when it gets wet / rare. Also, when the woman is involved in farm work, her engagement is classified into 3 levels: full / partial / low level of activity. In addition, farmers were asked about the traditional dairy products produced on the farms for their own consumption as cheese, butter, or other dairy products: (leben, raib-acidified milk, yoghurt, etc).

3. Analysis of milk quality and safety

Milk samples collection, microbiological content and physicochemical parameters analyzed in raw cow milk and sheep and goat milk samples in Algeria and Northwest Greece respectively were detailed in recent published papers (Allouche *et al.*, 2021; Pappa *et al.*, 2021).

In Northern Greece, cow milk samples were collected from 40 farms in the regional units of central Macedonia (Northern Greece); physicochemical analysis was performed using MilkoScan FT1-FOSS analytical, while in Egypt, buffalo and cow milk samples were collected from 9 and 39 milk shops respectively from Giza, Benisuef and Alexandria governorates, and analyzed for physicochemical parameters using Lactoscan, Ultrasonic milk analyzer (Stara Zagora, Bulgaria).

III – Results and discussion

1. Farm characteristics and management

Table 1 shows the characteristics and management of dairy farms in Algeria, Greece and Egypt, animal health problems, involvement of woman and dairy products produced on the farms.

Table 1. Dairy farm characteristics and management in Algeria, Greece and Egypt

		Algeria (Sétif; cattle farms) n = 50	Northwest Greece (Loannina region; sheep and goats farms) n = 52	Northern Greece (Central Macedonia; cattle farms) n = 40	Egypt (Behara, Faum and Sharkia governates; cattle farms) n = 11
Farm scale	– Small scale	+	+		+
	– Medium scale		+	+	
	– Large scale		+		
Most observed animal health problems	– Mastitis	+			+
	– Fertility			+	
	– Others		+		
Hand washing before milking	– Yes		+	+	+
	– No	+			
Change of animal litter	– Frequently		+	+	+
	– When the litter is wet	+			
	– Rarely				
Involvement of the woman in the farm work	– All activities	+	+		+
	– Partial activities	+		+	+
	– Few activities				
Traditional dairy products produced on the farms	– Butter	+		No product	+
	– Cheese	+	+	+	
	– Other products	+	+		+

n: number of visited farms.

In Algeria and Egypt, most visited dairy cattle farms were small scale, while they were medium scale in Northern Greece and in Northwest Greece, sheep and goat farms were small, medium or large scale. In fact, the number of animals raised in the farms depends on several factors such as farm surface, availability of natural fodder, feed price, milk purchase request and selling milk price, and the capacity of the farmers to recruit additional employees.

In Greece, farmers wash their hands and change frequently the animal litter, which explains the few cases of observed mastitis in dairy sheep-goat and cattle farms. Controversy, mastitis is the first health problem observed in Algeria where many farmers neglect hand washing before milking and the litter was not changed frequently. Likewise, mastitis is the first disease observed in the Egyptian dairy farms despite the fact that many farmers wash their hands before milking due to the lack of other hygiene farm practices.

Mastitis is an inflammation of the udder usually caused by bacterial infection and it is common in dairy herds causing important economic losses. It cannot be eradicated but can be reduced to low levels by good management of dairy cows. Many factors influence the frequency of mastitis infection and management is particularly important (Akam *et al.*, 1989). In fact, maintaining the sanitary condition of the barn is important for the production of good quality milk. Clean, dry and comfortable bedding condition is important to minimize the growth of pathogenic microorganisms (Gurmesa, 2015).

In the present report, analysis of dairy farmers allows us to identify the different gaps that constraint milk production in term of quantity, quality and safety to suggest an effective solution for each Mediterranean country. In fact, addressing weaknesses and gaps in post-production activities like milk handling, collection, storage and transportation is of equal importance to maintain and put forward the value-added during production phase (ILO, 2020). Therefore, it is important to make Algerian and Egyptian farmers aware about the importance of hygiene practices in order to reduce mastitis, and consequently reduce the loss of milk and use of antibiotics. It is urgent to provide them a clear and practical guide in Arabic language about the good hygiene practices in the farm. The guide could be distributed through the dairy cooperatives/associations and processors.

Since a long time, women have always helped her families in most of the work on farms in many rural communities in the word. From the results of the present studies held in the three Mediterranean countries, farmers were male in most of the cases; only 3 women were registered as owners of farms (7.5%) in the 40 dairy farms visited in central Macedonia (Northern Greece), although when inquiring the farmers on the staff employed on farm, 24 farm owners (60%) referred to their wives and/or daughters as members of the skilled personnel working on-farm. However, in the three countries, when women are involved in the farm work, often fulfill diverse roles on-farm, from calf feeding to milking cows, to help and assist their families by making many efforts and sacrifices. In Greece, women played a very important family role and showed a high sense of responsibility in making important decisions inside the family context. In most of the cases women were dedicated to their families and were transmitting the cultural traditions to the following generations. In Egypt, women used the surplus of milk production to make butter or cheese (Karish or Mesh) for home consumption or sale (neighbours or local markets) (Daburon *et al.*, 2016).

Regarding the production of dairy products on the farms, it seems that Algerian and Egyptian farmers produce butter, cheese, *leben* or *raieb* (acidified milk) for their own consumption. Nevertheless, Greek farmers who raise cattle sales all the milk without producing any product, while Greek farmers who raise sheep and/or goats produces cheese or yoghurts for their families. From these observations, it is clear the importance to produce good milk quality as it will not be only sold with high price to the processors but also participates to the nutrition and promotes food security and health for the rural communities.

2. Assessment of milk quality and safety

Physicochemical parameters and microbiological content analyzed in raw cow milk, sheep and goat milk were detailed in the recent published studies by Allouche *et al.* (2021) and Pappa *et al.* (2021). Milk physicochemical parameters analyzed in Northern Greece and Greek national cow milk samples in 2020 are presented in Table 2: while physicochemical analysis of buffalo and cow milk samples collected in Egypt from shops are shown in Table 3.

Table 2. Physicochemical parameters of cow milk samples collected in central Macedonia (Northern Greece) and national reference laboratories¹

Parameters	Cow milk samples collected from 40 farmers in Central Macedonia (Northern Greece)			Greek cow milk samples collected from national reference laboratories ¹
	Mean ± SE	Minimum value	Maximum value	Mean ± SE
Fat, %	3.915 ± 0.0200	3.48	4.34	3.905 ± 0.0102
Protein, %	3.327 ± 0.0060	3.19	3.44	3.320 ± 0.0038
Lactose, %	4.824 ± 0.0090	4.72	4.98	4.772 ± 0.0046
Solid in non-fat substance, %	8.835 ± 0.0101	8.66	9.02	8.808 ± 0.0072
Freezing point depression, °C	-0.5261 ± 0.0002	-0.523	-0.530	-0.5254 ± 0.0001
Colony forming units, CFU/ml x 1000	51.92 ± 2.383	15.5	99.5	64.11 ± 2.931
Somatic cell count, SCC/ml x 1000	384.048 ± 17.2815	128.7	723.4	333.289 ± 7.6255

¹ELGO-Dimitra (2021).

Table 3. Physicochemical parameters of Buffalo and cow milk samples collected from milk shops in Egypt

Parameters	Buffalo milk samples collected from milk shops (n = 39)			Cow milk samples collected from milk shops (n = 9)		
	Mean ± SE	Minimum value	Maximum value	Mean ± SE	Minimum value	Maximum value
Fat, %	6 ± 0.22	2.9	7.8	3.8 ± 0.23	2.33	4.94
Protein, %	3.8 ± 0.37	2.6	4.7	3.2 ± 0.12	2.68	3.73
Lactose, %	5.7 ± 0.13	3.9	7.1	4.8 ± 0.18	4.03	5.60
Solid in non-fat substance, %	10.3 ± 0.16	7	12.9	8.7 ± 0.32	7.33	10.20
Freezing point depression, °C	-0.7 ± 0.3	-0.8	0	-0.6 ± 0.02	-0.67	-0.45
Density	32.1 ± 3.03	22.7	44.8	29.6 ± 1.00	25.69	34.32

The results of the analysis of raw milk samples in Algeria showed that physicochemical parameters and microbiological content were in accordance of the recommended standard values. However clotting properties indicated that raw milk is suitable for cheese making, while milk quality in terms of protein and fat contents remain insufficient to reach the requirement of dairy processors to produce added-value dairy products (Allouche *et al.*, 2021).

In Northern Greece, physicochemical parameters analyzed in cow milk are close to those recorded in the national laboratories (Table 2). In fact, milk physicochemical parameters obtained in Northern Greece and Egypt are in accordance within the international recommended values (Muehlhoff *et al.*, 2013).

The analyzed sheep and goat milk samples were of good quality and safety in Northwest Greece. The future of the Greek sheep and goat dairy chain is promising despite high competition within and outside of the European Union (Pappa *et al.*, 2021).

The quality of the raw milk depends on many factors such as the health of the animal, the feed consumed, the milking conditions, the cleanliness of milk equipment, the temperature control from bulk tank through silo storage tank at the processing plant, the cleanliness of tanker and lines and finally the good handling practices at all points in the process are necessary. Detailed information can be found in FAO and IDF (2011) and FACE Network (2016).

Moreover, dairy producers have to deal with control measures imposed by the dairy processors, otherwise their milk is rejected.

Table 3 shows that in Egypt, buffalo milk is more nutritious than cow milk collected from shops as it contains higher fat, protein, lactose and solid in non-fat substance contents which are in agreement with those found by Hamad and Baiomy (2010). The availability of this kind of milk of high quality in the region probably made Egypt the leading producer of milk, cheese, and butter in the MedAgri region (MedAgri, 2020).

It is highlighted that protein and fat contents of cow milk samples collected in Algeria, Greece and Egypt were lower than those found in Poland and Germany (Kuczaj, 2001; CLAL, 2020), which constraint the dairy processors to produce a wide range of dairy products in these countries. In fact, the quality and amount of cheese obtained, not only per volume of milk but also per gram of protein in cheese milk, is important for the economic outcome of the dairy industry (Wedholm *et al.*, 2006). Nevertheless, this lack of high quality milk led many developed countries to import considerable volumes of cheese and butter from developed countries (around 42% and 11% of world imports in 2015-17, respectively; and these percentages will remain at similar levels in 2027 (OECD and FAO, 2018).

In Algeria, several varieties of camembert are produced with a good taste in recent years. In contrast, few varieties of butters and other types of cheese are produced by the dairy processors. Algeria is still not able to build economically viable dairy transformation businesses as there is not sufficient local dairy production in terms of quantity and quality. Moreover, several of the traditional cheeses as Klila, Bouhezza, takammerite, igouanesare endangered, for various reasons including the unavailability of fodder, the rural exodus and changing dietary habits (Boudalia *et al.*, 2020).

In Greece, most of the big companies have a parallel production of milk, yogurt and a variety of cheeses, but there are also many smaller companies producing individual products. These are mainly local cheese producers, producing Protected Designation of Origin (PDO) cheeses. Greece has 22 PDO cheeses, the most known being Feta, Kaseri, Graviera and Metsovone. Milk and cheese represent about 60% of the dairy production (Chasapis and Christodoulaki, 2007-2010). Egypt is one among the main consumers of butter and cheese (OECD and FAO, 2018), but few companies produce full fat cheese from whole milk. Egyptian traditional white cheeses include Talaga, Istanbul and Baramily cheeses. Milk and dairy products are part of a healthy Mediterranean diet which, besides cow's milk, also consists of sheep's, goat's and buffalo's milk-alone or as a mixture- as raw material (2004).

Regarding the milk safety, many chemical contaminants are present in milk and dairy products, as for example pesticides. The implementation of food safety and a regulatory law in dairy and plant farms is required to reduce chemical residues in milk and dairy products (Aytenfsu *et al.*, 2016). In many Mediterranean countries, there is a lack of analysis of milk contaminants. In Greece, there exist pesticide analysis laboratories under private or public statement that determine many pesticide residues using modern analytical instruments and established methods. In contrast, few laboratories exist in Egypt and Algeria to provide services on demand of clients. For producing a safe milk, the government must control milk pesticide content at least every season.

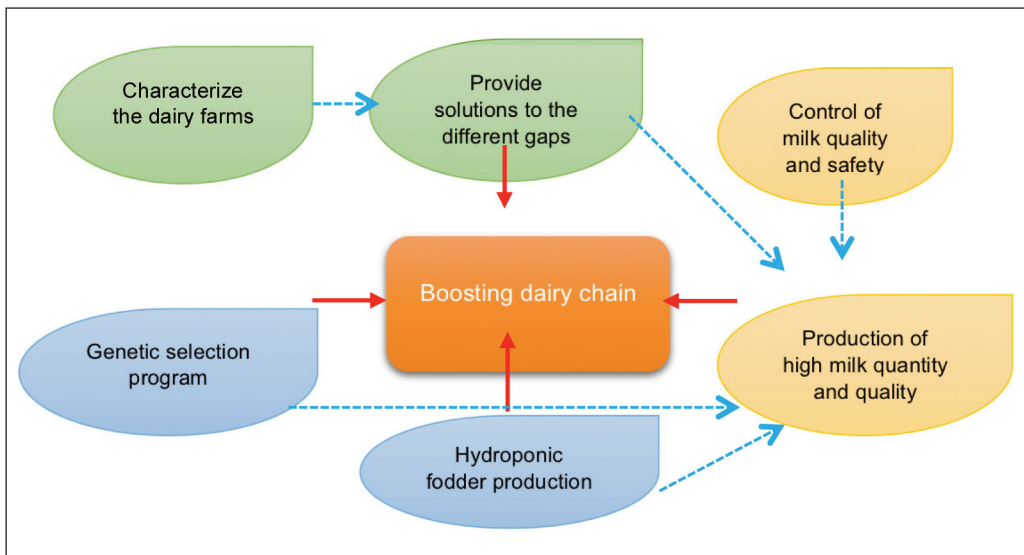
In the frameworks of our research activities, Algerian and Greek teams will collaborate with the Spanish team to analyze pesticides in milk samples using high technology to screen around 150 pesticides in milk samples. These analyses will inform the presence or not of pesticide related public health risks in these countries. It is important that Mediterranean countries collaborate together to assess these contaminants and promote health of Mediterranean populations.

3. Importance of new technologies to improve dairy production

In South Mediterranean region, and more specifically in Algeria and in Egypt, there are not consistent genetic programs to improve dairy cattle breeds, so it is important to start a program to improve cow genetics and select the best heifers who produce high milk quantity and quality, and being at the same time well adapted to the region climate. Algeria has not stopped importing heifers since its independence without satisfying the national milk requirements. Introducing a Marker-assisted technology in Algeria is one of the keys that could help developing dairy sector and would be later disseminated to other Mediterranean countries; this initiative would allow the breeders to identify the best cattle rearing in the area at young age who can produce high protein and fat milk contents, and start then a genetic program. To our knowledge, no cow genotyping laboratory exists in the Southern Mediterranean region; governments should encourage private companies to invest in the provision of tools and high technologies and facilitate their collaboration with breeders, cooperatives and international consultants as this technology is the fastest way to improve milk quantity and quality. Also, introducing fodder production in the arid and semi-arid regions would be a good opportunity for farmers to produce more feed and overcome drought periods. Many local seeds should be tested as wheat and barley to find the best seeds that produce more fodder quantity. In that sense, hydroponic fodder is a good solution to provide animal feed, particularly for small farmers that have a low availability of land and water mainly in dry season, hence it is crucial to know and disseminate this technique in the arid and semi-arid regions.

4. Strategies linking diagram

The following diagram presents an overview on strategies that would improve milk production, milk quality and safety; thus, boosting dairy processors in the Mediterranean region.



IV – Conclusions

The present paper revealed that most farms in Algeria and Egypt were operating at small scale, while at medium scale in Greece. However, in Northwest Greece sheep and goat farms were small, medium or large. Greek farmers respect well the hygienic practices which is not the case of Algerian farm-

ers; therefore, mastitis is not the most observed disease, whereas this disease is widespread in Algerian and Egyptian farms. Although few women are engaged in the work of the visited farms, these women participate in many farm activities from feeding to milking. In the three countries, dairy farmers produce many traditional dairy products for their families, except for Greek cattle dairy farmers who prefer selling all the milk. Sheep and goat milk quality is good, likewise cow milk physicochemical parameters are within the recommended values in all milk samples collected in Algeria, Greece and Egypt; however, the protein and fat contents cannot satisfy the dairy processors demand of high quality (particularly in terms of fat and protein contents). In Egypt, buffalo milk samples taken from shops were more nutritious than cow milk samples. It is necessary to provide guidelines of good practices for Algerian and Egyptian farmers to limit the mastitis in the farms. Also, governments should encourage private sector to invest in new technologies and initiate new actions for improving milk quantity, quality and safety, as genetic selection and hydroponic fodder production.

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