PD-ABZ-981

SEMI-ANNUAL PROGRESS REPORT

7th 6 Months (October, 2003 - March, 2004)

PROJECT NO.: **PCE-G-00-00-00029-00**

PROJECT TITLE: **MULTINATIONAL APPROACHES TO ENHANCE GOAT PRODUCTION IN THE MIDDLE EAST**

I. Technical Progress

I.A) Research Objectives

1) Determine chemical and bacteriological status of goat milk in the Middle East (Israel, Jordan, and Egypt)
2) Determine effects of subclinical intramammary infection on milk quality (Israel)
3) Transfer milk processing technologies (e.g., improvements in milk storage quality and introduction of new milk products) to goat farmers in the Middle East (Jordan, Egypt)
4) Characterize goat production systems and practices in the Middle East (Jordan and Egypt)
5) Characterize goat disease conditions in the Middle East (Jordan)
6) Introducing new technologies able to improve utilization of feed resources in the region either by increasing their nutritive value, conservation to critical times, or compressing it to be easy transferable (Egypt)
7) Improving goat productivity in areas of the northern Sinai of Egypt that do not have access to Damascus goats by distributing bucks or by using artificial insemination (Egypt)
8) Enhance local extension capabilities by technical training (Egypt)
9) Expanding project achievements through seminars and field days with Bedouins in the northern Sinai region (Egypt)

I.B) Research Accomplishments

JORDAN

Goat milk product studies and workshops

A workshop was conducted in the area of Goat Milk Technology. We trained goat farmers and some women on cheese manufacturing in Al Muager town (photos) are shown in Appendix A). We generated some research papers. Two have been submitted and accepted by the International Goat Conference, which will be held in Pretoria, South Africa (papers, full and short paper, are shown in Appendix B). We also wrote another paper that will be sent for publication (Appendix C). In addition, we are investigating the variation of chemical composition of milk and fresh cheddar and white cheese made from bulk cow, goat, and sheep milk during three lactation periods. Some of the data generated is under statistical analyses.

Lectures were given to goat farmers in Al Mauger and Engaira towns (On spot training on Dairy hygiene in the dairy plant at the town. Photos # 4, 5, 6) on Goat dairy technology (Photes # 1, 2, 3) (Appendix D).

ISRAEL

Research

The study of goat herds in Israel during the period of this report focused on continuing of sample collection and analyzing the data compiled along the project in three main areas. I. Analyzing the major factors that influence milk yield and consequently curd yield in Saanen and Shami x Anglo Nubian goats, the main breed and crossbreeds in Israel, aiming to determining payment schemes and consequently provide the farmer with some tools to monitor and improve its milk quality and quantity. II. Identify the changes in udder infections accrue during two-lactations in three Anglo Nubian goats' farms and III. Study the influence of CAE virus infection at age of first parturition on number of kids, milk yield, udder infections, second parturition and culling rate.

I. Three farms with 682 goats of different breeds (Saanen) and crossbreeds (Shami x Anglo Nubian) were surveyed. Animals in each flock were sampled once during March-April or during September-October. At each sampling time, third of the animals were 15-30 days post partum, third at the peak of lactation and third at the end of lactation before drying-off. In each group, about third were at the first, second and third or more lactation. Milk samples from each udder-half were tested for bacterial condition, California mastitis test (CMT), SCC and milk composition: fat, protein and lactose. Lactation number, days in milk (DIM), udder morphology (visual): normal, straggly, degenerated, or "drying-off" as well as milk yield, which was recorded by the owner up to 2 weeks before or after sampling time were tabulated. In all the farms animals were machine milked twice daily with post teat dipping at 5 a.m. and 3 p.m. Two goat farms kept its animals in an open shelter providing 4-m2 shaded slatted floor and 4-m2 concrete surfaced yard for each goat and food was offered in mangers located in the sheds. One goat farm browses with the herd and supplementary concentrate is offered at the milking parlor.

Since in goats there is natural drying-off period, it was interesting to obtain representing figures of the milk quantity, quality and its composition throughout the lactation. This information is of major importance as it influences the technological and economical value of the produced milk and products such as yoghurt and cheese. The outcome of this study when finalized might result in accurate data that will enable private producers to determine what and how to handle their milk along the year, while at the same time giving large milk collecting cooperatives tools to determine payment schemes for small ruminant milk. This study is at the end of its analysis and preparation of the data for publication.

II. Study was held from February 2002 to January 2004 with three Anglo Nubian goats' farms. At the time of first sampling, most goats were 100 or more days in milking. Overall 361 goats (96, 128 and 137) participated which were from first to eight lactations. Goats were milked until natural drying-off or were dried 60 days before the following parturition. During the study

time, in farm 1, goats were kidding in two periods: October of 2002 and/or April of 2003 while in farms 2 and 3, goats were kidding in December 2002 and/or January 2003 with an average of 1.8-2.2 kids/goat. Kids were removed immediately after birth. The distributions of the goats according to lactations: first, second or third or more, at the time of first sampling were. Farm one: 54; 15; 25; Farm two: 42; 15; 71 and Farm three: 43; 44; 50. In Farm one, all milking goats were tested monthly by udder halves for udder bacterial condition, SCC and milk gross composition: protein, fat and lactose by udder halves until draying-off. On the day of parturition, udder bacterial condition was tested in colostrums following by the tested noted above at 10 days post partum (PP) and every 4-5 weeks after until drying off or at the end of the study. In Farms 2 and 3, goats were tested once in mid lactation, before draying-off, 10-20 days PP and once again in the following mid lactation. At drying-off, goats which were found with bacterial udder infection, were treated intramammary with commercial cattle dry-off treatment (VETIPEN DC. Vetimex, Bladel, Holland), which is a combination of procaine benzylpenicillin (300 mg), nafcillin (109.65 mg) and dihydrostreptomycin (125 mg), a whole tube per udder half. Goats were machine milked twice daily with post teat dipping at 5 a.m. and 3 p.m. Average milk yield for the herd was 650 liter/goat/lactation with a daily yield of 1 to 5 L. In Farm 1, goats were kept in an open shelter providing 4-m2 shaded slatted floor and 4-m2 concrete surfaced yard for each goat and food was offered in indoor in mangers located in the sheds. The other 2 farms were forest grassing with 300 g grain supplementation at the milking parlor. This study is at the end of its analysis and preparation of the data for publication.

III. The influence of CAE virus infection in a young herd is still going on, where the goats are entering they're second kidding. After a second test of the CAEV data will be statistically analyzed.

Extension and Publications

During the period of the present report, the Israeli investigators continued to visit goat farms in order to conduct the experimental work and also continued to transfer the data as bacteriological findings, CMT testing and milk quality to the farmers and their veterinarians. A few more one-day seminars were held and data were disseminated to the Extension personnel.

A research paper entitled: "Changes in Milk Composition as Affected by Subclinical Mastitis in Goats" was accepted for publication in the Journal of Dairy Science (APPENDIX D).

EGYPT

This progress report focuses mainly on the most recent achievements of current activities of the project.

Activity 1: Follow up of flock performance under different production systems in the region

According to the questionnaire sheet designed for monthly visits data have been and still

recorded for each flock. Preliminary results of the reproductive and productive performance derived from these data are presented in the following Tables. The impact of introducing Damascus goat gene on the flock performance seems to be slightly differed according to the production system.

Table 1. Changes of body weight of does under the studied systems

Phase	Overall	System1	System2	System3
Breeding season (kg)	27.0	27.0	28.1	26.4
Early pregnancy (kg)	28.7	28.0	29.2	28.4
Late pregnancy (kg)	29.0	28.6	31.5	29.2
Early lactation (kg)	27.8	27.5	30	29.3

Table 2. Reproductive performance of the does under the studied production systems

Trait	Overall	System1	System2	System3
No. of farms	19	8	4	7
Total no. of does joined	179	65	28	86
Average flock size (doe/farm)	9.4	8.1	7.0	13.0
% of does concieved	77.8	81.5	71.4	76.7
% of does aborted	5.1	7.5	20.0	....
% of does kidded	73.2	75.4	57.1	76.7
Twining rate (%)	32.8	24.5	50	36.4

Table 3. Productive performance of the crossbred offsprings under the studied production systems

Trait	Overall	System1	System2	System3
Birth weight: (kg)				
Male	2.18	2.13	1.66	2.68
Female	2.18	2.10	2.17	2.14
Weaning weight: (kg)				
Male	8.41	8.57	5.18	13.6
Female	8.64	9.65	3.75	8.5
Pre-weaning daily gain: (gm)				
Male	70	70	50	100
Female	70	80	20	60

Table 4. Biological performance of the flocks under studied production systems

Trait	System1	System2	System3
No. of kids born/doe joined	0.94	0.54	1.09
No. of kids born/doe kided	1.24	1.50	1.42
Kg of kids born/doe joined	2.09	0.98	3.11
Kg of kids weaned/doe joined	8.53	3.39	9.98

Activity 2: Introducing new packages to improve goats production performance in the region

1- The nutritional packages early reported in the project are still introduced to some farms in new locations according to the request of the extention department staff.
2- Improving production performance through introducing Damascus goats is applied. Damascus bucks are distributed to a new group of goat breeders. The project is keen to offer vetrinary care for the flocks of those bedouins as a source of incenitive to encourage them to maintain collecting data on their flocks.

Activity 3: Activities of Goat's milk

Concerning the microbiology of goat milk, lactoperoxidase system (LPS) is one of the natural anti-microbial agents in milk and can be used as a method for preserving raw milk where refrigeration may not be available due to technical or economic reasons. Thus, the use of LPS as a temporary milk preservation has several advantages : simple, has a specific anti-bacterial effect and without any toxicological risks. Therefore, we plan to study some natural and microbial agents to improve microbiological quality of goat milk through a M. Sc. Thesis study. Milk samples were collected under complete aseptic conditions and sent to the microbiology lab in El-Arish which was established and well prepared to avoid any change in the bacterial count of milk.

Total aerobic bacterial count on standard plate count counter ajar, total entrobacterocase on Violet Red bile glucose ajar, lactic acid bactinol on URS ajar were determined. The milk samples were pastured at 80 C for 20 minute and aerobic spore forming bacteria as well as lactoperoxidase and lysosomes activity were determined. Complete clinical and Somatic cell count of each sample were determined using Milk Scan. To study the effect of LPS on the pathogenic microorganism that threat the human health we obtained the following microorganism; Listeria monocytogens. E. coli O:157. Salmonella typhimurium. Bacillus cereus and Yersinia enterocolitica, and their effects under studying. The previous mentioned microorganisms were detected in the milk samples by PCR technique via using specific primers for each type of them.

Activity 4: Training package activities

Arrangements were done to start the first training program for extension staff. Twenty one extentionists was invited, through the Agriculture Departments in the region, to start the training program on June 2004. The training will extend for 7 days to cover :

- Nutritional packages use to enhance nutritive value of agri-by-products.
- Tools to improve production performance of local goats (management & genetic).
- Evaluation of economic performance of the available production systems of goats.
- Production of heigenic milk (source of contamination and tool to protect)

Activity 5: Determination of genetic variations among dominated goats breeds in North Sinai Governorate

Genetic analysis using Random Amplified Polymorphic DNA (RAPD)-PCR markers was performed for studying the variations in goats of North Sinai Governorate using ten random primers to amplify DNA fragments of these goats. Fifty (50) goats were selected randomly from different ecotypes namely; Nearly Shami, Shami x Baladi and Baladi goats from different locations (El-Sheikh Zewaid, Wadi El-Arish, Nekhila and El-Hasana) belonging to North Sinai Governorate (Fig. 1). Genotype identification based on the variations in the morphological polymorphism (phenotypic characteristics). Full morphological parameters in terms of body length, height, heart girth, width, shape, colour .....etc. as well as some biochemical parameters (total proteins, albumin, Alanine transferase, aspartate transferase gamma globulin transferase, urea and createnine) in addition to milk yield were recorded for each selected goat supported with photos.

RAPD-PCR analysis was used for constructing parsimony tree depicting relationships among the different selected goats (Dendogram).

It was found that random selected goats were close proximately to each other. This result directed us toward the south area (Nekhil and El-Hasana, Fig.1) which are far from the Israeli board where the black bedouins goats are dominant. Blood samples as well were collected and their RAPD test performance in progress. Moreover, blood serum was collected from each selected goat where liver function and kidney function tests were applied.

Palestinian Authority

Three people have been employed to work on the project in addition to Dr. Ziad Abdeen of Al-Quds University:

Ph.D. researcher: Ran Nashashibi
M.S. researcher: Sylvia Hassanat
M.S. student: Amer Ayyad

A survey was conducted in the West Bank in order to determine numbers of goats and their owners. Two veterinarians were trained in conducting surveys and collecting milk from goats according to protocols developed at the Volcani Institute. Equipment has been purchased for the survey in order to test quality of milk and other data about the herds. A workshop is being planned in the near future with project participants of the Volcani Institute.

I.C) Scientific Impact of Cooperation

How the collaborating scientists participated in the project during the reporting period has been addressed above. The communications among the participants in findings at the different locations regarding similar areas of study is having positive impacts on all of the programs. As mentioned in the previous report, findings at the Israeli location regarding milk technologies are being used to determine most appropriate related activities at other locations.

During this last six months the Israeli and the PA team met at The Volcani Center and exchanged information related to future cooperation between the two teams. Part of a work proposed by the PA team was discussed and it was concluded that a second meeting would take place where testing and sampling procedures will be demonstrated in order to have similar experimental procedures.

In terms of Jordan University of Science and Technology an active partner of USAID/MERC funded regional goat project was proud to introduce four scientists from school of Vet-Medicine and Agriculture to this regional project to investigate the situation of goat industry status in Jordan as part of the Middle East. The University has encouraged the conduction of this research, through the international cooperation. The University also has displayed the necessary tools and facilities to make the mission easy to help its team to accomplish the job. Also the Administrative and the Consultative center were very supportive and helpful on all stages of this work. The top management of our University has permitted (the principle four team members to travel during the semester postponing lectures and research to participate in regional workshops out side the country and to interact with other working teams. On the other hand we noticed that public awareness about the project was profound at JUST, the community and among students, researchers and faculty members. Goat farmers in Ajloun, Bani-Kinanh and Jarash areas were the most interested, benefited and applauding people. This area of investigation (goat industry) have never been investigated before, the information about it never been exchanged with the neighboring Countries or discussed, the goat farming in the region has not been emphasized, the information also have never been shared with scientists in the region in such well organized plan before. The USAID/MERC funded project gave us the opportunity to be associated with international work. We feel that the Jordanian team is closer in cooperation with all teams involved in this project. The Jordanian team showed friendly relationships towards all team members used to participate in meetings and workshops, we had the opportunity to meet, dine, email, visit cards, reprints, exchanged gifts and fruitful ideas.

I.D) Project Impact

Results of this project are being used. Notable examples are the technologies transferred to goat farmers in the northern Sinai area by the Egyptian team. In October, Drs. Sahlu, Goetsch, and Merkel visited this area and many of the participating goat farms. The farmers were indeed very pleased with these new practices, namely manufacture and use of supplemental feed blocks made from locally available byproduct feedstuffs, ammoniation via urea treatment of crop residues, and ensilage of available byproduct feedstuffs containing anti-nutritional factors. In addition, there is great interest by Sinai goat farmers in crossbreeding with Damascus goats

available through this project. Farmers in Israel now are becoming increasingly aware of the high prevalence and appreciable impact of subclinical intramammary infection on goat milk yield and quality and, thus, are making appropriate production practice modifications. Results from the Jordanian team are also being used by producers. The workshops held in making goat cheese have improved production practices. Similarly, technology transfer on goat health management is enhancing disease prevention and treatment practices.

I.E) Strengthening of Middle Eastern Institutions

Evidence of strengthening of Middle Eastern institutions should be evident by information given earlier for each location in the "Research Accomplishments" section.

I.F) Future Work

OVERALL

The project is slightly behind schedule because of the length of time taken to get initial funds to the locations, occasional delays in subsequent fund transfers, and the current lack of funds available for planned activities in years 3, 4, and 5 of the project. The work plan has not been substantially changed. Because of initial milk quality findings in Israel, there has been justified attention given to subclinical intramammary infection and impacts on yield and quality of goat milk and cheese.

JORDAN

The future work will include mineral analysis of goat dairy products, the above mentioned cheddar cheese. Cheese will be produced using different rennin enzyme sources. Economic (cost) will be evaluated. The generated data and knowledge will be transferred to farmers. The previous knowledge regarding the new technology of cheddar cheese making will be transferred through workshops in other areas such as Bani Kananh, Jarash and Ajloun. Diffusion and adoption of the new technology will be preformed after these workshops will be investigated to evaluate the farmer's progress in terms of the rate of adoption, the relative advantage, compatibility, complexity, trial ability and observability by farmers.

ISRAEL

Future activities in Israel are addressed in the Research Accomplishment section.

EGYPT

Future activities in Egypt are addressed in the Research Accomplishment section.

PALESTINIAN AUTHORITY

Initial project activities for Al-Quds University are the same as those for other locations. A questionnaire will be used to characterize goat production in the West Bank. Milk samples

will be collected from different regions of the West Bank and analyzed for chemical and bacteriological properties. The possibility of a team member receiving Ph.D. training through this project at the Hebrew University of Jerusalem is being explored, with advisement by Israeli team member Dr. Nissim Silanikove.

II. Project Management and Cooperation

II.A) Managerial Issues

There are no managerial issues to be mentioned.

II.B) Special Concerns

No special concerns protocols have been changed.

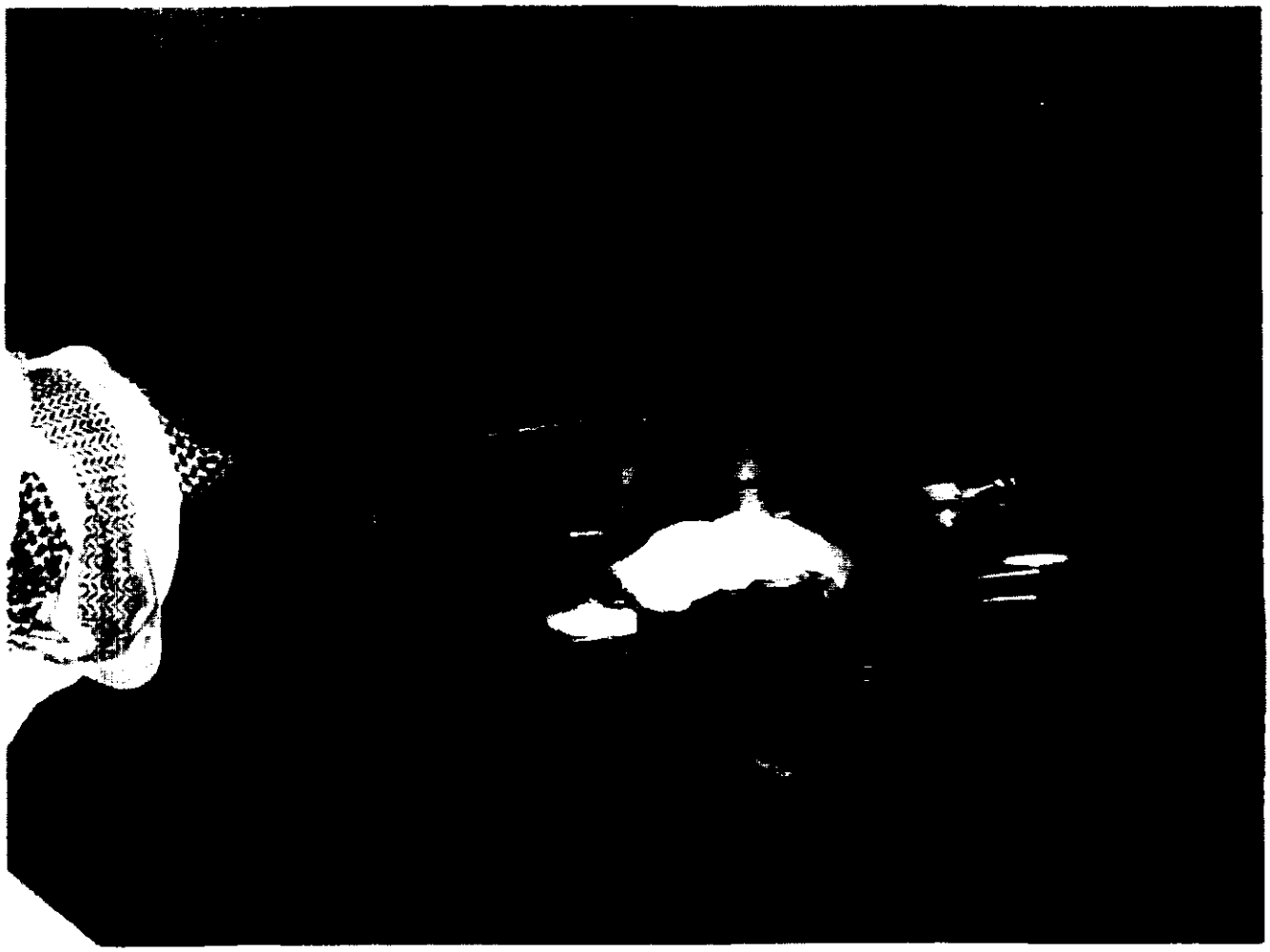
II.C) Cooperation, Travel, Training, and Publications

Publications are addressed in the Research Accomplishment section. A training function in Egypt on small ruminant management and record-keeping was scheduled for May, 2004. However, because it was only possible for Jordan University of Science and Technology project personnel to attend, the training session was delayed to August/September. In addition, a training function on artificial insemination is being planned by the Egypt team for the fall of 2004.

II.D) Request for USAID Actions

There are no current requests for USAID actions.

APPENDIX A



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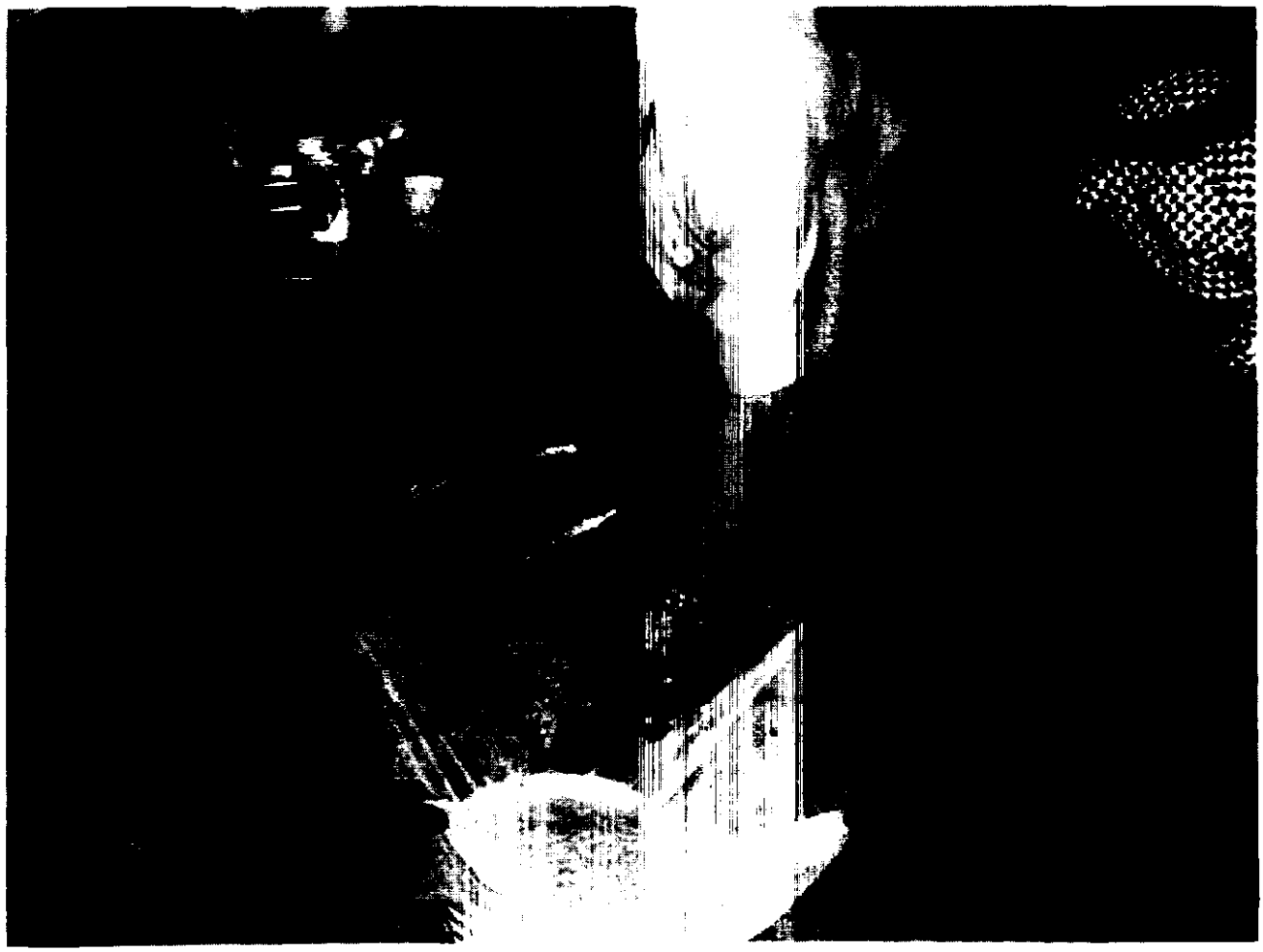

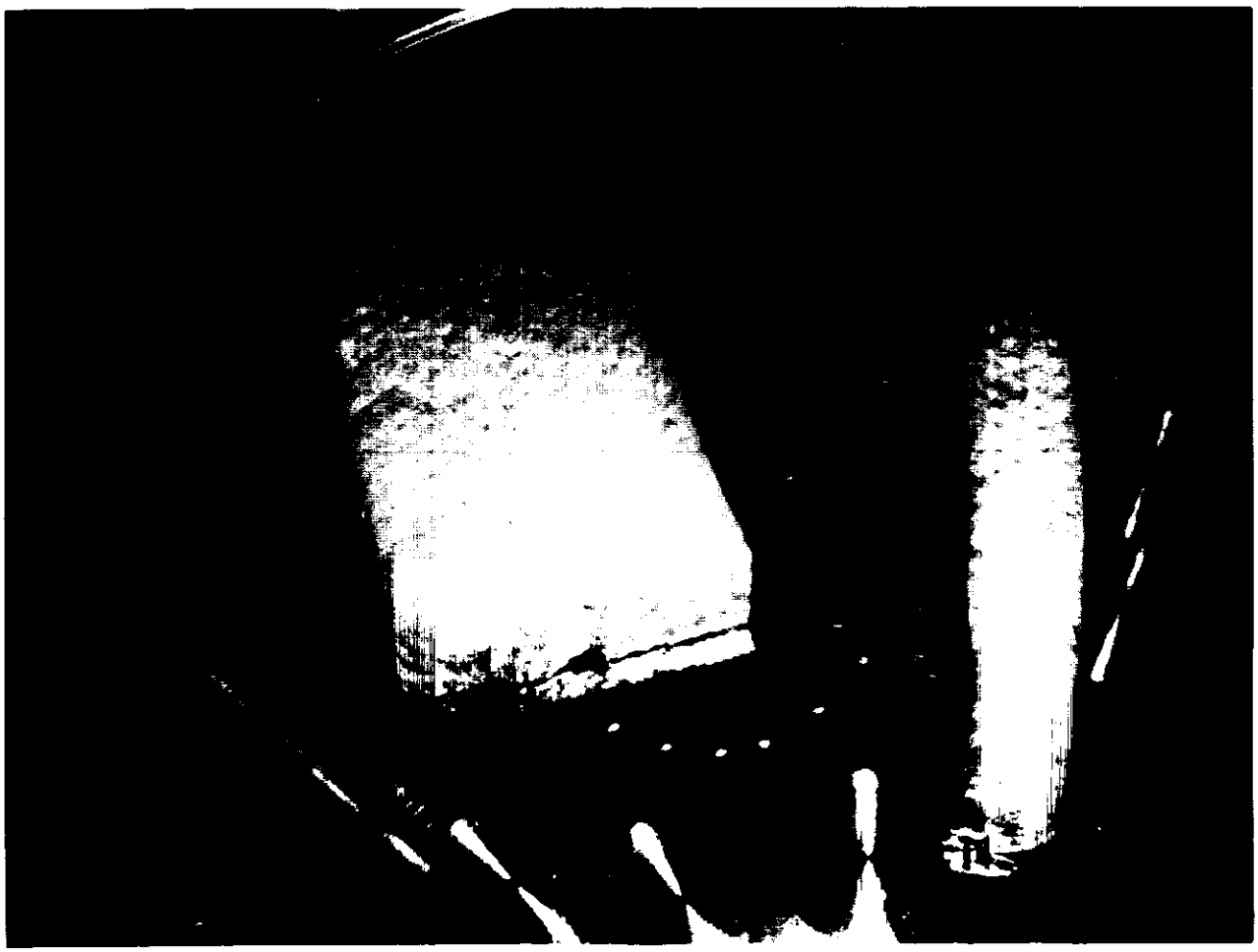

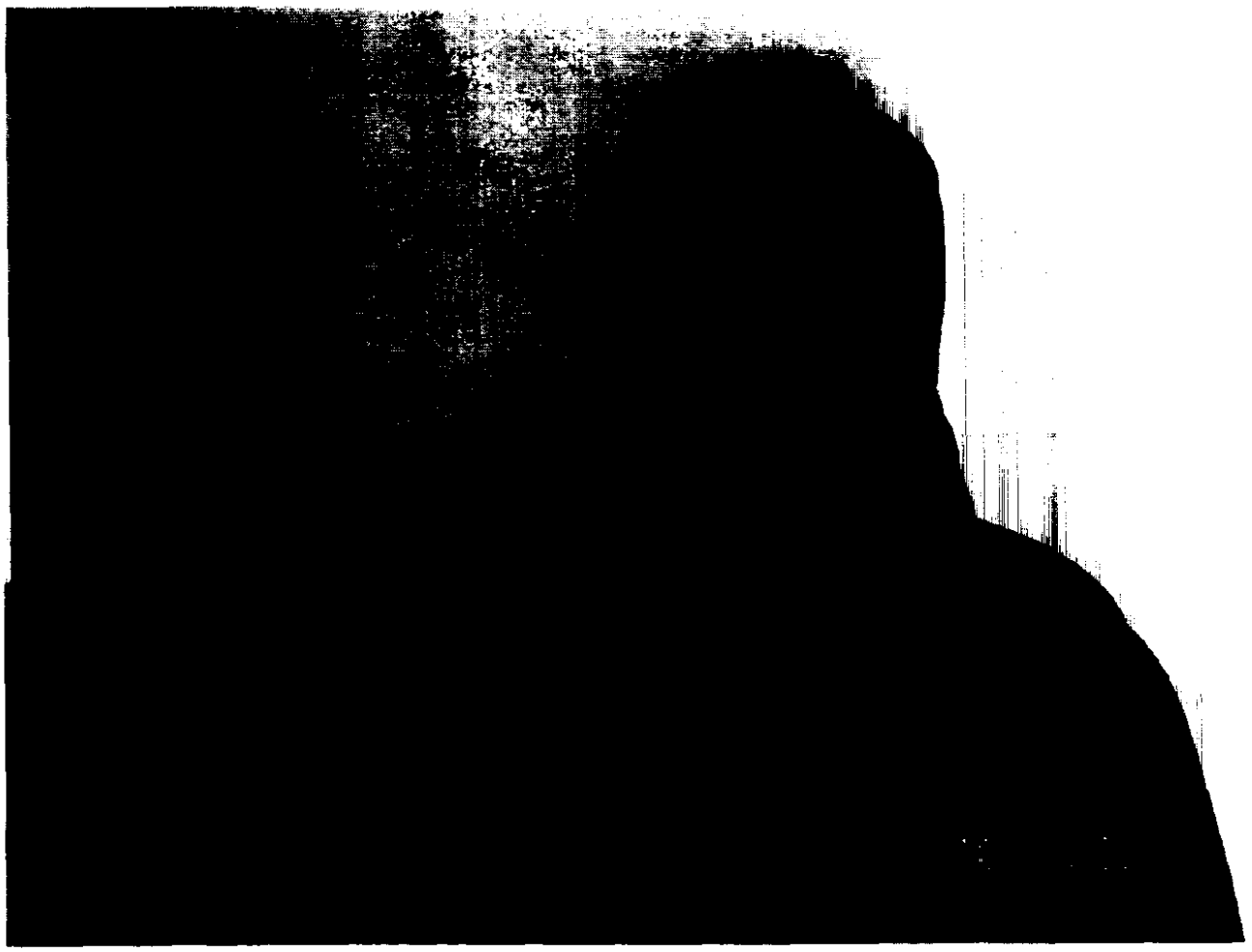

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APPENDIX B

Yield, Acidity and Organoleptic Characteristics of Traditional Dairy Products Manufactured From Goat Milk Using different Starter Cultures

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ABSTRACT

Milk samples, proximately 400 ml each, were collected from goat or sheep udder, milked by hand, from farms in Ajloun area once every week during the year 2003 and were tested for chemical composition. Cow milk was collected from The Agricultural Research Station located on the campus of Jordan University of Science and Technology. Other milk samples were collected from bulk (proximately 10 liters) for cheddar and white cheese manufacturing. Milk samples were transported on ice to laboratory and kept in refrigerator at 4° C until time of analysis which usually carried out at the same day. All goat and sheep animals were healthy, 3-5 years old and weighing 50-60 kg. Results of milk chemical analysis showed significant differences among the three animals' milk. Sheep milk was higher in protein and fat content followed by goat and cow milk. The milk composition also varied during the lactation periods but not significantly. Cheddar cheese chemical composition also varied significantly among the three animal's milk, but the variation during lactation periods was not significant. Fresh cheddar cheese made from goat milk was the highest in protein, ash and solids non fat, whereas sheep was intermediate and cow milk cheddar cheese was the lowest. White cheese made from cow, goat and sheep milk showed significant variation in their chemical analysis. Sheep cheese found to be the highest in fat, protein, ash, lactose and NSF content followed by cow and goat cheese. The organoleptic evaluation of cheddar cheese manufactured from cow, goat and sheep milk showed no significant variation in their color, appearance, taste or aroma. All cheeses had total acceptability scores ranging from 68.2 to 82.2. These results suggest that we can produce highly acceptable fresh cheddar cheese at any time during the lactation semesters of cow, goat and sheep in spite the variation in their milk composition.

Keywords: Cow, goat, sheep, milk, cheddar, cheese, lactation.

INRTODUCTION

About 8000 B.C. goat was the first animal species to be domesticated by the Sumerians in Mesopotamia. Goat had a strong impact on all phases of the Sumerian's life. Goat was considered by ancient people as a holy entity for worship at the side of gods. In modern times goats play an important economic role in farming, providing food for farmers in mountains, arid and semiarid areas (Hatziminaoglou and Boyazoglu 2004). Goats have spread all over the world adapting very well for diverse environments.

Traditionally it is very well known that Jordanians, like other Mediterranean people prefer to store their foods at home and to make it available to be used all the year around without frequent market visiting for food purchasing. During spring time, when the goat milk reaches the peak, Jordanians collect the goat milk and process it into traditional products such as white brined cheese, yoghurt, labaneh, jameed, ghee, and keshik. Other products such as butter and defatted yoghurt whey (called locally shanineh) are usually consumed and not stored as other products. The reason probably is that milk products are preserved in a way to maintain their quality without any spoilage or deterioration in their quality, taste and flavor. On the other hand, products such as butter (not pure butter) are susceptible to autoxidation and rancidity or further fermentation. That influences the taste, aroma and promotes acidity. The defatted yoghurt whey is usually susceptible to activity and growth of microorganisms due to its high moisture content.

The traditional goat milk products are stable and have a long shelf life, for instance labaneh (concentrated yoghurt balls) are preserved in glass jars covered with olive oil and it contains 2-3 % salt. Jameed and keshik are dry products and contain very low level of moisture and high salt content. Cheese made from goat milk is preserved also in tin containers or glass jars with 18 % salt solution.

Goat milk production ranks third in the world milk production after bovine and buffalo milk. Dairy goat farming plays an important role in developing countries. Goat milk provides one of the principle sources of animal protein in many regions, such as the Middle East, Southeast Asia and some tropical countries. Goat milk also serve as a good substitute to cow milk and is often recommended by the medical profession in situation where bovine may bring about allergic responses in individual consumers (Guo et al 1998).

Goat is very well adapted animal to diverse environmental conditions in Jordan. Goats are raised in small livestock in mountain and dessert areas to support the owning family. Goat milk is very popular in the Middle East and consumed as fluid milk at home or to produce the traditional milk products such as yoghurt, white brined cheese, labaneh, jameed, sour milk, keshik, butter, ghee and others. The goat milk industry is still considered home industry or business. The farmer family members are usually responsible for the work required by the livestock, such as feeding, management, animal medical care, milking, processing and marketing.

In the last thirty years the world livestock sector has evolved significantly. The numbers of animals have increased for meat and milk production (Boyazoglu and Morand-Fehr 2001). In 1998 the milk production from sheep reached eight million tons, the goat produced twelve million tons, and the cow and buffalo produced 500 million tons (FAO 1999). FAO (1999). Small ruminant milk production represents about 3.5% of the total milk produced in the world; the percent is greater in the developing countries (7.5%) as compared with the developed countries (1.5 %) FAO (1999). The relatively small impact can not be over looked, these milk and meat productions play an essential role in difficult and marginal environment such as the Middle East. Milk production in the developed countries remained stable during the last decade, but sheep and goat milk showed an upturn and showed an 11 and 21 % increase respectively. On the other hand cow milk production in the developing countries increased drastically almost by 77 %, sheep and goat milk production showed slower progress and increased by 18 and 38 % respectively (Boyazuglu and Morand-Fehr 2001). Sheep and goat milk production is considered a major activity in the Middle East. Goat milk has grown significantly in several countries such as India, Bangladesh, and Iran.

The Mediterranean countries produce 18 % of worldwide milk production. The annual goat milk production is 11 million tones. If sheep milk is added up, the worldwide milk production from goat and sheep milk will increase to 18 million tones (FAO 1998) which makes small ruminant milk production of major economic significant despite major dairy cattle population (Haenlein 2002). Large portion of goat milk is home consumed or processed into cheese and yoghurt or other traditional products as the case in Jordan, milk is used to produce Labaneh, Jameed, Keshik, Butter, Ghee and whey drink in addition to white cheese and yoghurt. Goat and sheep milk and their products are of great value from nutritional point view in the developing countries because they provide protein, fat and minerals to the diet in addition they support farmers in desert and mountains where cows may not be able to survive (Haenlein 1998).

Regarding the livestock numbers Haenlein and Abdellatif (2004) recently stated that during the last decade dairy cattle have increased (1.3 %), buffaloes (9.4 %), beef cattle (5.1 %), goat (21.3 %), chicken (26.6 %) and sheep decreased (10.8 %) whereas the numbers of people increased by 21.1 % during the same time. In developing countries the demand for meat and milk and its products is also increasing, some suggestions to achieve improvements in production has been reported and discussed (Haenlein and Abdellatif 2004).

Milking period is very important because a longer milking period extends the production season especially for mountain (Boyazoglu and Morand-Fehr 2001) and desert farmers. Goat has up to 300 days of milking whereas sheep have 250 milking days.

Because the goat farmers in Jordan lack the sound knowledge about milk technology and the acceptability of goat milk traditional products, we initiated a program to help them. The purpose of this investigation is to report on the acidity, yield and the organoleptic characteristics of goat milk traditional products such as yoghurt, labaneh, jameed, keshih, butter and ghee.

MATERIALS AND METHODS

Goat milk collection

Around 10 kg of goat milk were collected from goat farms in Ajloun area during spring of 2003. Milk samples were transported on ice to laboratory and kept in refrigerator at 4° C until time of processing which usually carried out at the same day. All goats were healthy, 3-5 years old and weighing 50-60 kg.

Traditional products manufacturing

Yoghurt, labaneh, jameed, keshik, butter and ghee were produced from goat milk according to the schematic diagrams in Figures 1-7. Three starter cultures were used in goat milk processing. The first culture was previously prepared yoghurt at home and this is called local starter. The second starter culture is (EZAL™) which was purchased from Rhodia Food ZA de Buxières- B.P.10, F. 86220 Dangè Saird Romain, France. The third starter culture was (Visbyvac® B 500) and was purchased from Busch-Johnnsen Str.1, D.25899 Niebull, Germany. Each product was replicated three times.

Acidity measurement

Titratable acidity was determined in yoghurt, labaneh, jameed, keshik, butter and ghee according to the procedure outlined by Richardson (1985). Where 5 g of yoghurt, labaneh, jameed and keshik were dissolved in neutralized distilled deionized water and titrated with 0.02 N NaOH using phenolphthalein as indicator. Ghee and butter samples were dissolved in a mixture of neutral ethyl ether and petroleum ether (1:1) and titrated againsi 0.02 N NaOH.

Yield Measurements

The yield of yoghurt, labaneh, jameed, keshik, butter and ghee was calculated as follow:

Yield % = Weight of the final particular product (kg)/ Weight of milk used (kg) x100

Sensory evaluation

A sample of yoghurt, labaneh, jameed, keshik, butter and ghee was introduced to be evaluated for acceptability to 25 untrained panelists for color (20), taste and flavor (30), texture and appearance (25), and aroma (25). Each organoleptic characteristic was given a score (between brackets). The panelists were asked to taste the product and give scores according to the likeness.

Statistical analysis

The collected data were subjected to statistical analysis using the randomized complete block design with three replicates and the means were compared at a probability of 5 %. The averages were compared and the LSD (least significant difference) between the means was computed according to Steel and Torrie (1982).

RESULTS AND DISCUSSION

Table 1 shows the animal numbers in some world regions. The data concerning milk production in Jordan were adapted from FAO 1999 and Boyazogln and Morand-Fehr 2001. The Jordanian Statistical Department showed different figures for cattle, sheep and goat milk. Therefore the true cattle milk production in1998 was 114.234 MT (Metric tones), and the combined sheep and goat milk production in the same year was 67.500 MT. We found no other data available and no statistics in this regard to present (DOS 1998). However the estimated number of goats in Jordan is slightly less than a million, but the DOS 1998 shows that the new born goats in1998 were 515,653. These data contradict with those reported previously (FAO 1999 and Boyazogln and Morand-Fehr 2001).

The chemical composition of cow, goat and sheep milk during three lactation semesters was reported previously (Ereifej 2004). The chemical analysis of goat cheddar and white cheese also were reported (Ereifej 2004).

Table 2 present data on acidity and yield of the traditional goat milk products. All those products are manufactured from fermented milk. Therefore the lactic acid concentration is very important because it determines the taste and acceptability of the dairy product. Lactic acid is produced by the added starter culture. The lactic acid level in the products depends on several factors such as the amount and type of starter bacteria, temperature and the duration of manufacturing steps.

The acidity in the products varied significantly as show in Table 2. The EZAL ™ produced less lactic acid in yoghurt and labaneh (1 and 1.6 % respectively), the Visby vac® produced 2.1 % in labaneh. This level of lactic acid is 1.0% higher than acidity level in yoghurt. The acidity of labaneh varied significantly. The EZAL™ produced 1.6 % which is 1.5 % less than other cultures. It seems that acidity contribute to the yield. Higher acidity leads to higher yield. As expected the acidity of butter was higher than that in the ghee. The butter obtained from goat milk using the procedure shown in Fig.5 is called locally balady butter which is preferred over the pure butter bars available on the supermarket shelves. That is because the color is white (not yellow), it has a mild acidic taste. Because balady butter contains milk protein and lactic acid in addition to milk fat, that will influence the taste, flavor and aroma. On the other hand ghee, which is made from butted, is boiled; proteins will be precipitated along with other constituents. The pure melted fat will solidify in the container after cheese cloth clarification. The small acidity level in the ghee is not due to lactic acid, it is probably due to some free fatty acids which might be freed during heating or originated from milk.

The yield of the traditional goat milk products is very important to the goat farmers from economic view point. Only yoghurt yielded the whole amount of milk, all other traditional products including the white brined cheese is manufactured from milk fractions or is milk fraction. Figures from 1 to 6 show the milk processing steps to produce

yoghurt, labaneh, jameed, keshik, butter and ghee. We can conclude the fact that during manufacturing the traditional dairy products nothing is lost as waste from the milk, all milk fractions are used as food.

Table 3 shows the data of yoghurt sensory evaluation. The local starter which is not pure yoghurt culture due to contamination by natural microflora during reusing the culture, have resulted in lass acceptable yoghurt. Visbyvac® resulted in yoghurt having better color, taste, appearance and aroma than EZAL™ and local cultures, the total scores were 83.7 followed by EZAL™ (76.7) then the local culture (69.3).

The three starter cultures used to produce labaneh resulted in highly acceptable product, although the total scores varied significantly. As shown in Table 4 the local culture performance was similar to Visbyvac® and better than EZAL™ However, Visbyvac® produced yoghurt similar to the most liked yoghurt produced by using the local culture, there for Visbyvac® can be recommended because it is dry and can be added directly to the milk.

As expected there were no significant differences in color, taste, appearance and aroma of jameed (Table 5) and keshik (Table 6). Probably the high level of salt made to look and taste the same. Further more salt might have masked the lactic acid taste in jameed.

The total scores for keshik were also as high as jameed's scores. They varied but not significantly Visbyvac® had the highest scores (87.0). The explanation for that might be due to lower level of salt as compared with jameed, and also the addition of boiled wheat grits which usually contribute to taste and aroma.

The data on sensory evaluation of butter made from goat milk treated with three starter cultures are presented in Table 7. Data show slight variation in color, taste, appearance and aroma but not statistically different. Butter obtained by using local starter culture gave slightly higher aroma scores than Visby vac® and EZAL™ , that difference was statistically significant. The explanation for this might be due to the fact that panelist were familiar with the local butter and they liked it over those made by using Visby vac® and EZAL™ new cultures. The beneficiary facts of the unique qualities of goat milk are just barely known and little exploited, especially not the high levels of short and medium chain fatty acids in goat milk fat which have been valued for many medical disorder and diseases of people (Haenlein 2004). Haenlein 2004 also stated that while goat yoghurt, cheese and milk powder are widely appreciated around the world, goat butter is not produced anywhere commercially in significant volume.

Ghee made from goat milk using three starter cultures showed different trend than butter. Color and appearance showed no significant variation. The taste, aroma and total acceptability showed significant variation (Table 8) for ghee produced from milk inoculated with Local and EZAL™. Aroma and total acceptability scores varied significantly, but all were highly acceptable. The starter cultures can be categorized according to ghee acceptability as Local (80.3), Visby vac® (76.7) and lastly EZAL ™ (76.6). Ghee is still like butter, not produced anywhere in the world on commercial bases in large volumes to recognize the health benefits of short and medium chain of fatty acids which are unique to goat milk.

Conclusions

The results of the present study confirmed that the chemical composition of goat milk is intermediate as compared with sheep and cow milk. Also the chemical composition of cow, goat and sheep milk varied significantly among the animals, also varied but not significantly during the lactation periods. Similar conclusions also were apparent to the fresh white and cheddar cheese manufactured from these milks. Also we found that it is possible to produce highly acceptable white and cheddar cheese at any time during lactation periods of cow, goat and sheep in Jordan.

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Table 1. **Cattles, Buffaloes, Sheep and goat numbers in some world regions (in million heads and milk production in Jordan, FAO, 1999)**

World Region	Cattle	Buffaloes	Sheep	Goats
Asia	**460**	**152**	**404**	**437**
Africa	**220**	**3.1**	**237**	**204**
USA	**480**	**1.5**	**115**	**40**
Europe	**150**	**0.2**	**159**	**18**
Oceania	**36**	**0.06**	**165**	**1**
Milk* production in Jordan	**123**	**-**	**34**	**21**

*** Million tones**

- No production

Table 2. Titratable acidity and yield of traditional goat milk products using three different starter cultures*

Starter culture Type	Acidity (%)	Yield (%)
	Yoghurt	
Local	1.1a	100a
Visbyvac®	1.3a	100a
EZAL ™	1.0a	100a
LSD ≤ P 0.5	0.3	-
	Labaneh	
Local	1.8a	35.7b
Visbyvac®	2.1a	40.3a
EZAL ™	1.6c	36.0b
LSD ≤ P 0.5	0.1	2.9
	Jameed	
Local	3.1a	14.8a
Visbyvac®	3.2a	10.8b
EZAL ™	2.6a	11.4b
LSD ≤ P 0.5	1.4	2.6
	Keshik	
Local	1.9b	12.9a
Visbyvac®	1.9b	11.2a
EZAL ™	2.3a	14.3a
LSD ≤ P 0.5	0.1	4.2
	Butter	
Local	0.6a	4.9a
Visbyvac®	0.4a	4.7a
EZAL ™	0.5a	5.8a
LSD ≤ P 0.5	0.4	1.3
	Ghee	
Local	0.13a	1.7a
Visbyvac®	0.13a	1.8a
EZAL ™	0.40a	2.1a
LSD ≤ P 0.5	0.60	0.5

a= Data are average of three replications.

***Values in columns followed by the same letter are not significantly different according to LSD**

Table 3. **Organoleptic characteristic of yoghurt made from goat milk using three different starter cultures** [a]

Starter culture	Color (20)	Taste (30)	Texture & appearance (25)	Aroma (25)	Total (100)
Local	14.7[c]*	17.0[b]	17.7[a]	18[b]	69.3[c]
Visbyvac®	18.0[a]	24.0[a]	20.7[a]	20.7[a]	83.7[a]
EZAL ™	16.7[b]	19.7[ab]	19.7[a]	21[a]	76.7[b]
LSDP<0.05	1.2	5.0	6.0	2.0	3.2

a= Data are average of three replications. *Values in columns followed by the same letter are not significantly different according to LSD

Table 4. Organoleptic characteristic of labaneh made from goat milk [a]

Starter Culture	Color (20)	Taste & Flavor (30)	Texture & Appearance (25)	Aroma (25)	Total (100)
Local	18.0[a*]	27.0[a]	22.7[a]	22.7[a]	90.3[a]
Visbyvac®	18.7[a]	27.0[a]	22.0[a]	22.0[a]	89.7[a]
EZAL ™	17.0[b]	23.7[b]	21.0[b]	22.0[a]	83.7[b]
LSD $P < 0.05$	0.8	2.0	0.8	0.8	3.0

a= Data are average of three replications. *Values in columns followed by the same letter are not significantly different according to LSD

Table 5. Organoleptic characteristics of Jameed made from goat milk[a]

Starter Culture	Color (20)	Taste (30)	Texture & appearance (25)	Aroma (25)	Total (100)
Local	18.7[a]	25.0[a]	21.7[a]	21.3[a]	86.7[a]
Visbyvac®	18.7[a]	24.7[a]	21.7[a]	20.7[a]	85.7[a]
EZAL ™	18.3[a]	25.0[a]	22.7[a]	21.0[a]	83.7[a]
LSD P<0.05	0.8	1.8	1.3	3.7	5.9

a= Data are average of three replications. *Values in columns followed by the same letter are not significantly different according to LSD

Table 6. Organoleptic characteristics of keshik made from milk goat using three different starter cultures[a]

Starter cultures	Color (20)	Taste & Flavor (30)	Texture & Appearance (25)	Aroma (25)	Total (100)
Local	16.7[a]	25.0[a]	21.7[a]	21.7[a]	84.0[a]
Visbyvac®	17.0[a]	25.7[a]	22.7[a]	21.7[a]	87.0[a]
EZAL ™	16.0[a]	24.7[a]	21.7[a]	21.0[a]	83.3[a]
LSD $P < 0.05$	1.8	1.8	1.3	1.2	4.3

a= Data are average of three replications. *Values in columns followed by the same letter are not significantly different according to LSD

Starter culture	Color (20)	Taste & Flavor (30)	Texture & Appearance (25)	Aroma (25)	Total (100)
Local	17.0[a*]	22.3[a]	21.3[a]	21.3[b]	82.0[a]
Visbyva®	16.7[a]	23.0[a]	20.0[a]	19.3[b]	77.7[a]
EZAL ™	16.0[a]	22.3[a]	21.3[a]	19.3[b]	78.0[a]
LSD P <0.05	1.8	3.5	1.8	1.6	6.6

Table 7. Organoleptic characteristics of butter made from goat milk using three different starter cultures [a]

a= Data are average of three replications. *Values in columns followed by the same letter are not significantly different according to LSD

V3

Table 8. Organoleptic characteristics of ghee made from goat milk using three different starter cultures [a]

Starter culture	Color (20)	Taste & Flavor (30)	Texture& Appearance (25)	Aroma (25)	*Total* (100)
Local	16.0[a*]	23.0[a]	20.7[a]	20.7[a]	80.3[a]
Visbyvac®	15.7[a]	21.0[b]	19.7[a]	19.7[ab]	76.7[ab]
EZAL ™	16.0[a]	22.7[a]	19.0[a]	19.0[b]	76.0[b]
LSD $P < 0.05$	2.9	1.2	1.8	1.2	4.1

a= Data are average of three replications. *Values in columns followed by the same letter are not significantly different according to LSD

Goat Milk
↓
Heat milk (85-90 °C)
↓
Cool (45 °C)
↓
Add starter (1-1.5%)
↓
Incubate for 2-3 hr. (45-48 °C)
↓
Yoghurt

Figure 1. Schematic diagram shows yoghurt production from goat milk

Goat Milk
↓
Yoghurt
↓
Add salt to yoghurt (1-3%)
↓
Pour in cloth bag
↓
Drain the serum (several hr)
Might apply some pressure
↓
Fill in container and refrigerate or
↓
Mould into balls and
Preserve in olive oil
in glass jars

Figure 2. Schematic diagram shows labaneh production from goat milk

Goat Milk
↓
Yoghurt
↓
Transfer yoghurt into churner
↓
Churn the yoghurt for 45 min
↓
Collect the butter
↓
Collect the defatted yoghurt
↓
Transfer to cloth bag
↓
Drain until soft curd forms
↓
Add 14 % salt and mix
↓
Prepare round shape (ball) and sun dry
↓
Dry hard balls are jameed

Figure 3. Schematic diagram shows jameed production from goat milk

Goat Milk
↓
Yoghurt into
Churner
↓
Add water (1 L water per
3 Kg yoghurt)
↓
Churn yoghurt for 45 min
↓
Add ice to churner
↓
Collect the formed butter
↓
Press to remove whey
↓
Add 1-1.5 % salt
↓
Fill and seal

Figure 4. Schematic diagram shows butter production from got milk

Butter
↓
Add 1-3 % salt
↓
Add 0.5 kg boiled wheat
grits per 3 kg butter
↓
Boil until becomes yellow or
to form foams
↓
Filter into glass jar and seal

Figure 5. Schematic diagram shows ghee production from goat milk

Goat Milk
↓
Yoghurt
↓
Add water and ice
Churn
↓
Collect the defatted whey
from the Churner
↓
Pour on enough boiled wheat
grits
↓
Add 1.5- 2 % salt
↓
Mix to obtain thick paste
↓
Prepare slaps by hand
↓
Sun dry the slabs
↓
Dried keshik

Figure 6. Schematic diagram shows keshik production from goat milk

APPENDIX C

Chemical Composition, Microbiological Quality and Sensory Characteristics of Milk, Cheddar and White Cheese Obtained From Three Goat Phenotypes during Three Lactation Periods

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Abstract: Goat's milk from three phenotypes: Shami (red), Local (black) and Mixed (colored) was collected during three lactation periods in 2002. The milk was analyzed for moisture, protein, fat, ash and lactose content. Also milk was examined for yeast, mold and bacterial content. Cheddar and white cheese were manufactured from goat's bulk milk and examined for chemical composition and evaluated for color, taste and flavor, appearance and texture and aroma. Results showed that the chemical composition of goat's milk varied significantly during the whole year and also among the three goat phenotypes. Local (black) goats produced milk at the first lactation period with highest (44.6 %) fat content, the lowest fat content was 29.8 % for the Mixed color phenotype at the end of the year. Protein showed the same trend. Shami goat produced milk lower in lactose and ash content than the mixed color breed, whereas the Local (black) produced milk having intermediate content of lactose and ash. Cheddar and white cheese were highly acceptable. Their composition varied, cheddar cheese was higher in protein and NSF but slightly lower in fat content. White cheese retained more lactose. Goat's milk of Shami, Local (black) and Mixed color phenotypes were found to be highly contaminated with bacteria and mold due to lack of hygiene. Milk contained low number of pathogenic bacteria. Pasteurization temperature at 73° C for 16 sec found to eliminate them.

Key Words: Goat, Milk, Cheese, Phenotype, Lactation, Composition, Microbiology

Introduction

The goat's milk production ranks third in the world after bovine and buffalo milk. Dairy goat farming plays an important role in developing countries. Goat's milk provides one of the principle sources of animal protein in many regions, such as the Middle East, Southeast Asia and some tropical countries. Goat's milk also serves as a good substitute to cow's milk and is often recommended by the medical profession in situation where bovine milk may bring about allergic responses in individual consumers. Goat is a very well adapted animal to diverse environmental condition in Jordan. There are few breeds of goats raised in Jordan. The Local (black) goat which is known as Balady, Shami goat which is red in color and from Syrian origin (also known as Damascus goat) and the Mixed or colored goat which is a product of crossing between Local and Shami goats or other hybrids. Balady (Local) goat is of Jordanian origin whereas Shami has been introduced to Jordanian farmers from Syria due to its milk productivity. Goat farming is considered as an important socio-economic activity in Jordan. There are one million heads, mainly Local (black), Shami and their hybrid goat phenotypes. Goats in Jordan are raised for milk, meat and hair production. Goats are raised in small livestocks. Goat milk is very popular in the Middle East and used to be consumed as liquid milk or

to produce the traditional dairy products such as yoghurt, white cheese, labaneh, Jameed, sour milk, kishek, butter, ghee and others. The goat milk industry is still considered home industry; the farmer and his family members are usually responsible for feeding, management, animal medical care, hand milking, processing and marketing the products. The demand for meat and milk in the Middle East is increasing and is projected at 3.7 and 3.1 % respectively. Because the goat farmers in Jordan lack the sound knowledge about milk technology, farming systems and management we initiated a program to help them, there for the purpose of this work is to study the microbial and chemical composition of milk and cheese obtained from three goat breeds, also to report on the variation on the chemical composition of goat milk during lactation periods.

Materials and Methods

Goat milk samples, proximately one liter each, were collected from farms in Ajloun area once every week during the year 2002-2003.

Chemical analysis: Goat's milk samples were subjected to chemical analysis, moisture, fat, protein (N x 6.38), ash and solid non fat (NSF) were determined according to standard procedures. Lactose content was calculated by difference. Averages were recorded for each lactation period. Lactation periods were proposed as First semester or lactation period to cover goat's milk collected during Jan. Feb. March and April. The second lactation semester started May, June, July and August. The third lactation period covered Sept., Oct. Nov. and December. The same procedures were used to analyze white and cheddar cheese made from bulk goat's milk during the same lactation periods.

Microbiological analysis: Goat's milk samples also were subjected to microbiological analysis. To determine TPC (total plate count), yeast, mold, *Staphylococci*, *S. aureus*, *Streptococci*, *Enterobacter*, *E. coli*, coliforms, *Salmonella* and *Shigella*.

Cheddar cheese manufacturing: Ten kg of goat milk were used to produce around one kg of cheddar cheese. Yoghurt starter, annatto and rennet enzyme were used.

White cheese manufacturing: Ten kg of goat milk were pasteurized at 73° C for 16 seconds, and then cooled to 35° C, rennet was added. Curd was formed after 40 min; curd was cut into small cubes and separated from the whey. The curd was pressed overnight. Curd was cut into 4x5 cm and covered with dry salt for 24 hr. Cheese cuts were removed from the salt and kept in brine (12 % salt).

Sensory evaluation: Cheddar cheese was evaluated for acceptability by 25 panelists for color (20), taste and flavor (30), texture and appearance (25), and aroma (25). Each property was given a score (shown between brackets). The yield was computed and the titratable acidity was performed by titrating 5 g milk with 0.1 N NaOH.

Statistical analysis: The collected data were subjected to statistical analysis using MSTATC computer program (MSTATC program, Michigan State University). The averages were compared and the LSD (least significant difference) between the means was computed.

Results and Discussion

The chemical composition of goat's milk varied significantly among Shami, Local (black) and Mixed phenotypes and lactation periods. The chemical composition of pooled milk collected from each 6-10 goat phenotype during each lactation semester. The protein content of Shami goat varied significantly from lactation semester to lactation semester during the year. Protein content ranged from 17.3 at the end of lactation to 23.7 % at the first four lactation months. It was noticed also that the milk protein and other milk components varied from week to week or from month to month. Milk obtained from Local (black) contained higher protein than milk obtained from Shami goat and ranged from 24.6 (first semester) to 20.6 % (at the second semester). Protein content was the highest in milk collected from the Mixed (colored) breed at the first lactation semester (25.6 %). Shami goat was introduced to Jordan due to its high milk productivity. The Local black goat phenotype is known for its low milk production but it is favored for its meat. Fat content varied significantly and ranged from 44.6 for the first semester milk of Local (black) breed to 29.8 % for the third lactation semester of the Mixed goat breed. Lactose content also varied significantly and ranged from 44.9 for third semester of Mixed breed to 25.9 % for milk obtained from Local (black) at the first semester. Sung et. al. 1998 reported that the major milk components varied significantly among goat breeds (Alpine, Nubian, Saanen and Toggenburg). Data on protein, fat, and in lactose are in agreement with similar values reported by other investigators. Goat flocks raised by Jordanian farmers involve a mixture of Local, Shami and Mixed phenotypes. Farmers pool the milk collected from the whole flock and either sell or process it into traditional (Laban, Labaneh, white cheese, Jameed, butter milk, butter, ghee and kishek). These products are marketable. A sample from bulk milk was drawn every week during three lactation periods to be tested for chemical composition. Another sample was taken to produce cheddar cheese and to examine its chemical

composition. Table 2. show the data on bulk milk chemical composition. Fat, protein, ash, lactose and nonsolid fat contents found to vary significantly during lactation periods. Protein content of bulk milk was found to be the highest during the second semester (20.5 %) and lowest during the first semester (19.1 %). Fat contents also varied significantly and found to be the highest (35.8 %) during the third lactation semester and lowest during the second semester (32.3 %). Ash content did not show significant variation during the one year lactation period. Ash content ranged from 6.3 to 5.6 %. These data are in agreement with data reported recently on ewe, goat and cow's milk composition.

Lactose and SNF varied significantly and the highest values for lactose and NSF are reported for the second lactation period (41 and 67.7 %, respectively). The major components of goat milk varied significantly during the lactation periods. It is obvious the milk content of protein, fat, lactose and ash are influenced by several factors such as breed, nutrition, animal health, management and environment. Jordanian goat farmers follow the open system because goat industry is expensive and the goat farmers cannot afford it. They relay on free grazing.

Although differences in protein, fat, ash, lactose and NSF content. The differences were not statistically different during the lactation periods. Cheddar cheese made from goat milk was subjected to sensory evaluation. The differences in milk composition were reflected on the manufactured white and cheddar cheese. The chemical composition of cheese varied but not significantly as affected by lactation period. Those data are in agreement with similar data reported on Spanish goat's milk cheese (Armada variety). As expected, cheddar cheese made from bulk goat's milk during three lactation periods did not differ significantly in color, appearance, taste and texture or aroma. The total scores ranged from 68.2 (third semester) to 76.8 (first semester). Although panelists are very familiar with the white cheese, but not the cheddar. All of them tasted to the first time the goat's cheddar cheese. Probably that might explain the non significant variation in sensory evaluation of cheese characteristics. The goat cheddar cheese was acceptable during the three milking periods and scored higher than 75 % except for the third lactation semester (68 %).

Data on chemical composition of white cheese made from bulk goat milk showed no significant variation for all major bulk milk components except for ash content which varied significantly during the whole lactation period. The explanation for that might be due to utilizing the bulk milk which is usually a mixture of milk from individual animals in the goat flock which involves more than one breed. Cheese quality is influenced by two important factors: milk composition and the effect of ripening. The values reported in this investigation on cheese chemical composition are in agreement with similar values reported previously on twenty types cheese, the Gjetost cheese of Norway which is made from goat milk has 13.4 % moisture, 42.6 % lactose, 29.5 % fat, 9.6 % protein and 4.8 % ash. The total plate count (TPC), yeast and mold found to be present in goat's milk all the year around. TPC ranged from 1.3×10^5 to 4.1×10^5 cfu/ml. Yeast count ranged from 3.1×10^3 (milk obtained from mixed breed) to 7.9×10^5 cfu/ml (milk obtained from Shami goat). Mold count was also high and ranged from 1.7×10^3 to 8.7×10^3 cfu/ml. *Staphylococci* was found to range from 6.4×10^3 (Mixed goat breed milk during the second lactation semester) to 3.5×10^3 cfu/ml *S. aureus* was reported only once during the whole year at the first lactation period of the mixed colored goat breed. *Streptoccoci* bacteria were found in the milk of the three breeds all the year around ranging from 10^3 (first lactation period of the mixed color breed) to 5.4×10^3 cfu/ml (milk of the Local black milk at the second lactation semester). *E. coli* and some other bacteria from six hundred animal foods including unpasteurized goat milk have been isolated by some investigators. The microorganisms in traditional Greek cheese prepared from raw goat milk have been studied and reported the occurrence of aerobic, Enterobacteriaceae, Coliforms, Staphylococci, lactic acid bacteria, Enterococci and Yeast. The number of these organism found to be reduced as storage temperature is reduced from 15 C to 4 C. The values reported in this investigation lower than the mean values reported by other investigators.

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Chemical Composition, Microbiological Quality and Sensory Characteristics of Milk, Cheddar and White Cheese Obtained From Three Goat Phenotypes during Three Lactation Periods

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Abstract: Goat's milk from three phenotypes: Shami (red), Local (black) and Mixed (colored) was collected during three lactation periods in 2002. The milk was analyzed for moisture, protein, fat, ash and lactose content. Also milk was examined for yeast, mold and bacterial content. Cheddar and white cheese were manufactured from goat's bulk milk and examined for chemical composition and evaluated for color, taste and flavor, appearance and texture and aroma. Results showed that the chemical composition of goat's milk varied significantly during the whole year and also among the three goat phenotypes. Local (black) goats produced milk at the first lactation period with highest (44.6 g/100g) fat content, the lowest fat content was 29.8 g/100g for the Mixed color phenotype at the end of the year. Protein showed the same trend. Shami goat produced milk lower in lactose and ash content than the mixed color breed, whereas the Local (black) produced milk having intermediate content of lactose and ash. Cheddar and white cheese were highly acceptable. Their composition varied, cheddar cheese was higher in protein and NSF but slightly lower in fat content. White cheese retained more lactose. Goat's milk of Shami, Local (black) and Mixed color phenotypes were found to be highly contaminated with bacteria and mold due to lack of hygiene. Milk contained low number of pathogenic bacteria. Pasteurization temperature at 73° C for 16 sec found to eliminate them.

Key Words: Goat, Milk, Cheese, Phenotype, Lactation, Composition, Microbiology

Introduction

The goat's milk production ranks third in the world after bovine and buffalo milk. Dairy goat farming plays an important role in developing countries. Goat's milk provides one of the principle sources of animal protein in many regions, such as the Middle East, Southeast Asia and some tropical countries. Goat's milk also serves as a good substitute to cow's milk and is often recommended by the medical profession in situation where bovine milk may bring about allergic responses in individual consumers (Guo et al., 1998).

Goat is a very well adapted animal to diverse environmental condition in Jordan. There are few breeds of goats raised in Jordan. The Local (black) goat which is known as Balady, Shami goat which is red in color and from Syrian origin (also known as Damascus goat) and the Mixed or colored goat which is a product of crossing between Local and Shami goats or other hybrids. Balady (Local) goat is of Jordanian origin whereas Shami has been introduced to Jordanian farmers from Syria due to its milk productivity. Goat

farming is considered as an important socio-economic activity in Jordan. There are one million heads, mainly Local (black), Shami and their hybrid goat phenotypes. Goats in Jordan are raised for milk, meat and hair production. Goats are raised in small livestocks. Goat milk is very popular in the Middle East and used to be consumed as liquid milk or to produce the traditional dairy products such as yoghurt, white cheese, labaneh, Jameed, sour milk, kishek, butter, ghee and others. The goat milk industry is still considered home industry; the farmer and his family members are usually responsible for feeding, management, and animal medical care, hand milking, processing and marketing the products. The demand for meat and milk in the Middle East is increasing and is projected at 3.7 and 3.1 g/100g respectively.

Because the goat farmers in Jordan lack the sound knowledge about milk technology, farming systems and management we initiated a program to help them, there for the purpose of this work is to study the microbial and chemical composition of milk and cheese obtained from three goat breeds, also to report on the variation on the chemical composition of goat milk during lactation periods.

Materials and Methods

Goat milk samples, proximately one liter each, were collected from farms in Ajloun area once every week during the year 2002-2003 to be tested for chemical composition and microbial content. Samples were transported on ice to laboratory and kept in refrigerator at 4° C until time of analysis which usually carried out at the same day. Goat's milk samples were collected from three breeds. Shami (red in color), Local (black) and Mixed (colored). All animals were healthy, 3-5 years old and weighing 50-60 kg.

Other milk samples were collected from bulk to examine the composition of bulk milk and also to test for cheddar and white cheese manufacturing.

Chemical analysis: Goat's milk samples were subjected to chemical analysis, moisture, fat, protein (N x 6.38), ash and solid non fat (NSF) were determined according to standard procedures (Richardson (1985). Lactose content was calculated by difference. Averages were recorded for each lactation period. Lactation periods were proposed as First semester or lactation period to cover goat's milk collected during Jan. Feb. March and April. The second lactation semester started May, June, July and August. The third lactation period covered Sept., Oct. Nov. and December. The same procedures were used to analyze white and cheddar cheese made from bulk goat's milk during the same lactation periods.

Microbiological analysis: Goat's milk samples also were subjected to microbiological analysis. To determine TPC (total plate count), yeast, mold, *Staphylococci*, *S. aureus*, *Streptococci*, *Enterobacter*, *E. coli*, coliforms, *Salmonella* and *Shigella*. Standard procedures were followed (Vanderzant and Splittstoesser, 1992). The averages of cfu/ml (colony forming unit per ml) were recorded.

Cheddar cheese manufacturing: Ten kg of goat milk were used to produce around one kg of cheddar cheese. A small water bath and small cheese vat (45x40x25 cm) were used to represent double jacketed cheese vat. Yoghurt starter, annatto and rennet enzyme were used and the cheese were prepared according to the standard procedure (Kosikowski, 1982).

White cheese manufacturing: Ten kg of goat milk were pasteurized at 73° C for 16 seconds, and then cooled to 35° C, rennet was added. Curd was formed after 40 min; curd was cut into small cubes and separated from the whey. The curd was pressed overnight. Curd was cut into 4x5 cm and covered with dry salt for 24 hr. Cheese cuts were removed from the salt and kept in brine (12 g/100g salt). White cheese pieces were subjected to chemical and microbiological analysis.

Sensory evaluation: Cheddar cheese was evaluated for acceptability by 25 panelists for color (20), taste and flavor (30), texture and appearance (25), and aroma (25) as shown in Table 4. Each property was given a score (shown between brackets). The panelist was asked to taste the cheese and a high score to be given if it has been liked and a lower score if it has not been liked by the panelist. The yield was computed and the titratable acidity was performed by titrating 5 g milk with 0.1 N NaOH.

Statistical analysis: The collected data were subjected to statistical analysis using MSTATC computer program (MSTATC program, Michigan State University). The averages were compared and the LSD (least significant difference) between the means were computed (Steel and Torrie, 1982).

Results and Discussion

The chemical composition of goat's milk varied significantly among Shami, Local (black) and Mixed phenotypes and lactation periods as shown in Table 1. Data in Table 1. show the chemical composition of pooled milk collected from each 6-10 goat phenotype during each lactation semester. The protein content of Shami goat varied significantly from lactation semester to lactation semester during the year. Protein content

ranged from 17.3 at the end of lactation to 23.7 g/100g at the first four lactation months. It was noticed also that the milk protein and other milk components varied from week to week or from month to month. Milk obtained from Local (black) contained higher protein than milk obtained from Shami goat and ranged from 24.6 (first semester) to 20.6 g/100g (at the second semester). Protein content was the highest in milk collected from the Mixed (colored) breed at the first lactation semester (25.6 g/100g). Shami goat was introduced to Jordan due to its high milk productivity. The Local black goat phenotype is known for its low milk production but it is favored for its meat.

Fat content as presented in Table 1. varied significantly and ranged from 44.6 for the first semester milk of Local (black) breed to 29.8 g/100g for the third lactation semester of the Mixed goat breed. Lactose content also varied significantly and ranged from 44.9 for third semester of Mixed breed to 25.9 g/100g for milk obtained from Local (black) at the first semester. Sung et. al. 1998 reported that the major milk components varied significantly among goat breeds (Alpine, Nubian, Saanen and Toggenburg). Data on protein, fat, and lactose shown in Table 1. are in agreement with similar values reported by other investigators (Sung et al., 1998, Devendra, 1972, Park, 1991 and Zeng and Escobar 1996).

Goat flocks raised by Jordanian farmers involve a mixture of Local, Shami and Mixed phenotypes. Farmers pool the milk collected from the whole flock and either sell or process it into traditional (Laban, Labaneh, white cheese, Jameed, butter milk, butter, ghee and kishek). These products are marketable. A sample from bulk milk was drawn every week during three lactation periods to be tested for chemical composition. Another sample was taken to produce cheddar cheese and to examine its chemical composition. Table 2. show the data on bulk milk chemical composition. Fat, protein, ash, lactose and nonsolid fat contents found to vary significantly during lactation periods. Protein content of bulk milk was found to be the highest during the second semester (20.5 g/100g) and lowest during the first semester (19.1 g/100g). Fat contents also varied significantly and found to be the highest (35.8 g/100g) during the third lactation semester and lowest during the second semester (32.3 g/100g). Ash content did not show significant variation during the one year lactation period. Ash content ranged from 6.3 to 5.6 g/100g as shown in Table 2. These data are in agreement with data reported recently (Malau-Aduli et al., 2003) and with data reported on ewe, goat and cow's milk composition (Hadjipanayiotou, 1994).

Lactose and SNF varied significantly and the highest values for lactose and NSF are reported for the second lactation period (41 and 67.7 g/100g, respectively) as shown in Table 2. The major components of goat milk varied significantly during the lactation periods. It is obvious the milk content of protein, fat, lactose and ash are influenced by several factors such as breed (Zeng, 1996), nutrition, animal health, management and environment. Jordanian goat farmers follow the open system because goat industry is expensive and the goat farmers cannot afford it. They relay on free grazing.

The data on chemical composition of cheddar cheese made from bulk goat's milk are presented in Table 3. Although differences in protein, fat, ash, lactose and NSF content are shown in Table 3. The differences were not statistically different during the lactation periods. Cheddar cheese made from goat milk was subjected to sensory evaluation. The differences in milk composition were reflected on the manufactured white and cheddar cheese. As shown in Table 3,7 the chemical composition of cheese varied but not significantly as affected by lactation period. Those data are in agreement with similar data reported by Fresno et al 1995 on Spanish goat's milk cheese (Armada variety).

Table 4. shows the data on sensory evaluation. As expected, cheddar cheese made from bulk goat's milk during three lactation periods did not differ significantly in color, appearance, taste and texture or aroma. The total scores ranged from 68.2 (third semester) to 76.8 (first semester). Although panelists are very familiar with the white cheese, but not the cheddar. All of them tasted to the first time the goat's cheddar cheese. Probably that might explain the non significant variation in sensory evaluation of cheese characteristics. The goat cheddar cheese was acceptable during the three milking periods and scored higher than 75 g/100g except for the third lactation semester (68 g/100g).

The chemical composition of white cheese made from bulk goat milk is presented in Table 5. Data show no significant variation for all major bulk milk components except for ash content which varied significantly during the whole lactation period. The explanation for that might be due to utilizing the bulk milk which is usually a mixture of milk from individual animals in the goat flock which involves more than one breed. Cheese quality is influenced by two important factors: milk composition and the effect of ripening (Boyazoglu and Morand-Fehr 2001). The values reported in this investigation on cheese chemical composition are in agreement with similar values reported previously (Haenlein, 1998 and Posati and Orr, 1976). Haenleina (1998) reported the gross analysis of twenty types of cheeses, the Gjetost cheese of

Norway which is made from goat milk has 13.4 g/100g moisture, 42.6 g/100g lactose, 29.5 g/100g fat, 9.6 g/100g protein and 4.8 g/100g ash.

Data on microbiological examination of goat milk are shown in Table 6. The total plate count (TPC), yeast and mold found to be present in goat's milk all the year around. TPC ranged from $1.3x10^5$ to $4.1x10^5$ cfu/ml. Yeast count ranged from 3.1×10^3 (milk obtained from mixed breed) to 7.9×10^5 cfu/ml (milk obtained from Shami goat). Mold count was also high and ranged from 1.7×10^3 to $8.7x10^3$ cfu/ml. *Staphylococci* was found to range from $6.4x10^3$ (Mixed goat breed milk during the second lactation semester) to 3.5×10^3 cfu/ml. *S. aureus* was reported only once during the whole year at the first lactation period of the mixed colored goat breed. *Streptoccoci* bacteria were found in the milk of the three breeds all the year around ranging from 10^3 (first lactation period of the mixed color breed) to $5.4x10^3$ cfu/ml (milk of the Local black milk at the second lactation semester) as shown in Table 6.

Dontorou et al., (2003) reported on the isolation of *E. coli* and some other bacteria from six hundred animal foods including unpasteurized goat milk. Psoni et al., (2003) also investigated the microorganisms in traditional Greek cheese prepared from raw goat milk, and reported the occurrence of aerobic, Enterobacteriaceae, Coliforms, Staphylococci, lactic acid bacteria, Enterococci and Yeast. The number of these organism found to be reduced as storage temperature is reduced from 15 C to 4 C. The values reported in this investigation lower than the mean values reported by Psoni et al., (2003).

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Table 1. **Chemical composition of goat milk collected at three lactation periods from Shami, Balady and Mixed goat phenotypes** [a]

Goat Breed	Lactation Semester	Protein (g/100g)	Fat (g/100g)	Lactose (g/100g)	Ash (g/100g)
	1	23.7[a]	44.3[a]	26.0[c]	5.2[c]
Shami (red)	2	18.3[cd]	39.8[ab]	35.6[b]	5.0[c]
	3	17.3[c]	35.1[bc]	34.9[b]	5.5[bc]
	1	24.6[a]	44.6[a]	25.9[c]	5.0[c]
Local (black)	2	20.6[bc]	44.5[a]	34.4[b]	5.5[bc]
	3	22.7[ab]	35.0[bc]	40.5[a]	6.0[ab]
	1	25.6[a]	35.3[bc]	34.1[b]	5.2[c]
Mixed (colored)	2	17.6[cd]	34.4[bc]	41.6[a]	6.4[a]
	3	18.9[cd]	29.8[c]	44.9[a]	6.4[a]
LSD P<0.05		3.1	5.8	4.7	0.7

a= Data are average of 16 samples collected through four months as a sample per week and computed on dry weight basis

***Means in columns followed by the same letter are not significantly different according to LSD**

Table 2. **Chemical composition of goat milk collected at three lactation periods** [a]

Lactation Semester	NSF (g/100 g)	Ash (g/10 0g)	Lactose (g/100g)	Protein (g/100g)	Fat (g/100g)
First semester	63.1[b]	5.6[a]	38.4[b]*	19.1[b]	37.0[a]*
Second semester	67.7[a]	6.3[a]	41.0[a]	20.5[a]	32.3[b]
Third semester	64.2[b]	6.2[a]	38.8[b]	19.3[ab]	35.8[a]
LSD $P < 0.05$	2.9	1.6	2.2	1.3	2.9

a= Data are average of 16 samples collected through four months as a sample per week and computed on dry weight basis

***Means in columns followed by the same letter are not significantly different according to LSD**

Table 3 . **Chemical composition of cheddar cheese made from bulk goat milk collected at three lactation periods**

Lactation Semester	Protein (g/100g)	Fat (g/100g)	Ash (g/100g)	Lactose (g/100g)	NSF (g/100g)
First Semester	38.7[a]	35.0[a]	10.5[a*]	15.8[a]	65.0[a]
Second Semester	37.2[a]	38.6[a]	10.2[b]	14.1[a]	65.1[a]
Third Semester	38.0[a]	36.9[a]	10.3[ab]	14.9[a]	63.2[a]
LSD $P < 0.05$	1.8	10.1	0.3	10.0	11.5

a= Data are average of 16 samples collected through four months as a sample per week and computed on dry weight basis

***Means in columns followed by the same letter are not significantly different according to LSD**

Table 4. **Sensory characteristic of cheddar cheese made from bulk goat milk collected at three lactation periods (data average of 16 samples and computed on dry weight basis)[a]**

Lactation Semester	Color (20)	Appearance (15)	Taste (30)	Texture (15)	Aroma (20)	Total (100)
First semester	17.8[a]	10.5[a]	23.4[a]	10.8[a]	14.3[a]	76.8[a*]
Second Semester	18.6[a]	12.0[a]	22.2[a]	8.3[a]	15.0[a]	76.0[a]
Third Semester	14.3[a]	8.3[a]	21.3[a]	9.3[a]	14.8[a]	68.2[a]
LSD $P < 0.05$	5.3	5.8	9.3	4.0	5.3	23.4

a =Data are average of 16 samples collected through four months as a sample per week and computed on dry weight basis

***Values in columns followed by the same letter are not significantly different according to LSD**

Table 5. **Chemical composition of white cheese made from bulk goat milk collected at three lactation periods** [a]

Lactation Semester	Protein (g/100g)	Fat (g/100g)	Ash (g/100g)	Lactose (g/100g)	NSF (g/100g)
First Semester	25.6 [a]	39.6 [a]	9.4 [a]	25.4 [a]	60.1 [a*]
Second Semester	26.1 [a]	43.3 [a]	9.6 [b]	20.7 [a]	56.2 [a]
Third Semester	26.0 [a]	41.6 [a]	9.6 [ab]	23.0 [a]	58.5 [a]
LSD $P < 0.05$	0.6	4.1	0.3	5.8	4.1

[a] = Data are average of 16 samples collected through four months as a sample per week and computed on dry weight basis

*** Means in columns followed by the same letter are not significantly different according to LSD**

Table 6 . ***Microbiological analysis of milk obtained from three goat breeds during three lactation periods****

Goat Breed	Lactation semester	TPC	Yeasts	Molds	*Staphylococcus*	*S. aeureus*	*Streptococcus*	*Enterobacteriacea*	*E. coli*	*Coliforms*	*Salmonella*	*Shigella*
	1	$1.7x10^5$	$3.3x10^4$	nd	$2.0x10^3$	-	$1.7x10^3$	$6.9x10^4$	-	nd*	_	_
Shami	2	$4.1x10^5$	$7.9x10^5$	$1.4x10^3$	$1.9x10^3$	-	$4.8x10^3$	$2.8x10^6$	-	$3.6x10^2$	_	_
	3	$2.7x10^5$	$6.4x10^5$	$3.7x10^3$	$3.5x10^3$	-	$2.8x10^3$	$6.5x10^2$	-	$5.2x10^1$	_	_
Local	1	$1.9x10^5$	$4.4x10^4$	9.1	$2.3x10^3$	-	$4.4x10^3$	$7.3x10^4$	+	nd	+	_
	2	$2.2x10^5$	$5.2x10^5$	$4.2x10^3$	$2.2x10^3$	-	$5.4x10^3$	$3.6x10^4$	+	$1.2x10^2$	_	_
	3	$1.3x10^5$	$1.2x10^5$	$8.7x10^3$	$2.8x10^3$	-	$2.8x10^3$	$6.5x10^3$	+	$9.3x10^1$	_	_
	1	$3.8x10^5$	$3.1x10^3$	9.1	$1.6x10^3$	+	$1.0x10^3$	$2.4x10^4$	-	nd	_	_
Mixed	2	$4.7x10^4$	$1.4x10^5$	nd	$6.4x10^2$	-	$1.2x10^3$	Nd	-	nd	_	_
	3	$2.0x10^5$	$1.6x10^5$	$7.5x10^3$	$2.8x10^3$	-	$5.2x10^3$	$7.2x10^3$	+	$9.4x10^1$	_	_

***= Data are average of 16 samples collected through four months as a sample per week.**

*** - =Not detected**

Table 7. **Microbiological examination of cheddar cheese**

Lactation semester	TPC	Yeasts	Molds	Streptococci	Other Bacteria
First semester	$4x10^4$	$5x10^4$	-*	$2x10^4$	-
Second semester	$3x10^4$	$7x10^4$	-	$1x10^4$	-
Third Semester	$6x10^4$	$5x10^4$	-	$1x10^4$	-

a= Data are average of 16 samples collected through four months as a sample per week

*** = Not detected**

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APPENDIX D

Figure 1.The Agricultural Directorate at Al Muager Town (The place of the meeting)

Figure 2. The principle investigator (Dr. Ereifej) is giving a lecture to goat farmers on dairy technology.

Figure 3. The principle investigator (Dr. Ereifej) is giving a lecture to goat farmers on dairy technology.

Figure 4.On spot training on diary products quality

Figure 5.On spot training on diary products quality

Figure 6.On spot training on diary products quality

Appendix D

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Changes in Milk Composition as Affected by Subclinical Mastitis in Goats

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ABSTRACT

The mechanism of the effects of subclinical mastitis (SM) at the glandular level in dairy goats on milk yield and its composition as expressed in curd yield (Yc) was studied. Twenty-five Israeli goats of various crossbreeds were chosen; one udder half was naturally infected with identified coagulase-negative staphylococci, and the contralateral gland was free of bacteria.

The milk yield of the infected halves was significantly lower than that of the uninfected ones. Somatic cell count and N-acetyl-β-D-glucosaminidase activity were significantly higher in the infected halves. The lactose concentration in the infected glands was significantly lower than that in the uninfected ones, casein concentrations did not differ, and the whey protein and albumin concentrations were significantly higher in the infected glands.

Plasmin activity was significantly higher in the infected glands, whereas plasminogen activity was undetectable. Concentrations of Ca^{2+} did not differ, whereas Ca^{2+} activity was significantly lower in the infected glands. The proteose peptone concentration was 1.5 times as great in the infected glands as in the uninfected ones. The Yc was significantly lower in the infected halves, and clotting time was significantly longer.

The mechanisms of the effects of SM on milk yield and Yc in goats and sheep are discussed and compared. (**Key words:** subclinical mastitis, goat, milk composition)

Abbreviation key: a_{Ca}^{2+} = calcium activity, CN = casein, **CNS** = coagulase-negative staphylococci, **p-p** = proteose peptones, **PA** = plasminogen activator, **PL** = plasmin, **PLG** = plasminogen, **SM** = subclinical mastitis, **Tc** = clotting time, **Yc** = curd yield.

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INTRODUCTION

The proportion of udder halves with subclinical IMI in goats in different countries ranges from 35 to 70% (Menzies and Ramanoon, 2001; Leitner et al., accepted). In Israeli dairy goats, the main pathogen group in infected udder halves comprises various species of coagulase-negative staphylococci (**CNS**), mainly *Staphylococcus caprae* and *Staphylococcus epidermidis* (Leitner et al., accepted). A survey of 20 Israeli-Assaf dairy sheep (Leitner et al., 2003) revealed similar results; the main influence on SCC was IMI, and milk yield was significantly higher in uninfected than in infected halves. However, a direct comparison between infected and uninfected glands was not possible in that study because the measurements were based on the whole udder level and not on a single gland level. Therefore, a glandular level model was developed in which each animal had one udder half infected with an identified CNS species, and the contralateral gland was free of bacteria, to focus on how subclinical mastitis (**SM**) affected milk yield and compositional changes in relation to curd yield (**Yc**) (Leitner et al., accepted). Applying this experimental design in sheep showed that subclinical IMI was associated with increased plasminogen activator (**PA**) and plasmin (**PL**) activities as a result of accelerated conversion of plasminogen (**PLG**) to PL in the infected glands. These changes were associated with accelerated apparent casein (**CN**) degradation, reduced Yc, and increased milk-clotting time (**Tc**). These modifications indicate that the changes in milk composition negatively affect the yield and quality of cheese made from milk that originates from infected glands.

Plasmin is the main proteolytic enzyme in cow and sheep milk (Politis, 1996; Leitner et al., accepted) in which it occurs mostly as the inactive zymogen PLG,

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which is activated by PA. However, only residual PLG activity was found in goat milk, which was consistent with the unusually high PA activity compared with values for ovine and bovine milk. Nevertheless, PA and PL activities in late-lactating goats were negatively correlated with the coagulating properties of milk, which suggests that this system is important in goats as well (Fantuz et al., 2001).

The present study applied the glandular level model to dairy goats to test the effect of IMI on milk yield and on milk quality as reflected in Yc and Tc. To achieve this goal, animals were chosen that had one udder half infected with an identified CNS species and the contralateral gland free of bacteria. In each gland, inflammation indices were analyzed along with total milk protein, CN, whey proteins, the PA-PL system activity, and measures of proteolysis.

MATERIALS AND METHODS

Animals

Twenty-five Israeli goats of various crossbreeds, mainly Shami × Anglo Nubian and Saanen × Anglo Nubian, in which one udder half was naturally infected with an identified single species of CNS and the contralateral gland was bacteria free, were selected from 2 flocks. Prior to animal selection, milk samples from each udder half were subjected to 3 consecutive weekly examinations to test for bacterial infection, SCC, and NAGase activity. The selected goats were 40 to 120 d post-kidding, and their daily milk yield exceeded 2.5 L. In both farms, the goats were machine milked twice daily at 5 a.m. and 3 p.m. Post teat dipping was practiced, and they were kept in an open shelter that provided 4 m^2 of shaded slatted floor and 4 m^2 of concrete-surfaced yard for each goat. Feed was offered in mangers located in the sheds.

Milk Sampling and Analysis

The milk sampling and yield measurements were carried out during the morning milking. Yield was determined by weighing the milk of each udder half of each goat after hand milking. For the bacteriological tests and NAGase activity measurements, the teats were cleaned and disinfected, and the milk was sampled and analyzed as described by Leitner et al. (accepted). Three additional sets of samples were taken from each udder half and distributed for analysis as follows. One set was preserved by means of Broad Spectrum Microtabs® II (D & F Control Systems, Inc., CA) and sent to a central laboratory (Cattle Breeders Association Laboratory, Caesarea, Israel) for analysis of the milk gross composition—protein, fat, and lactose contents—with the Milkoscan 6000 and analysis of the SCC with a Fossomatic 360 (Foss Electric, Hillerød, Denmark); both were calibrated with goat milk. The second set of samples was used to determine Yc and Tc; Tc was measured according to Berridge (1952). A third set was defatted, and the skim milk was used for analysis of CN concentration, whey proteins, albumin, and proteose peptones (p-p) (Shamay et al., 2000b, 2003) and for PA, PLG, and PL activities (Silanikove et al., 2000). The repeated addition procedure was used to measure the concentrations of free (ionized) calcium ($[Ca^{2+}]$) and the uncorrected procedure was used to determine calcium activity (a_{Ca}^{2+}) in these samples within 5 h of sampling by means of a specific calcium electrode (Silanikove et al., 2003).

Bacteriological Examinations

Bacteriological analysis was performed according to accepted standards (Hogan et al., 1999). From every milk sample, 0.01 mL was spread onto blood agar plates (Bacto-Agar; Difco Laboratory) containing 5% of washed sheep red blood cells and on MacConkey plates. All plates were incubated at 37°C and examined for growth after 18 and 42 h. Colonies suspected to be staphylococci were tested for coagulase (tube test) (Anilab, Rehovot, Israel). Strain identification was carried out with the API STAPH-IDENT, 32 Staph kit (bioMerieux S.A., 69280 Marcy-l'Etoile, France). When the percentage of micrococci-like bacteria that matched the test strain exceeded 90%, the strain was regarded as specific.

Yc Determination

Curd yield was determined according to Leitner et al. (2004); Fromase 15 TL (Gist-Brocades nv, Delft, The Netherlands) was used as the coagulating enzyme. To determine the accuracy of the Yc measurement, Yc was measured for a sample in both dry and wet states. The dry curd was tested according to Melilli et al. (2002), whose procedure was modified by weighing the wet curd after centrifugation and drying it overnight in an oven at 100°C. The curd sample was not transferred to another container for drying, as suggested by Melilli et al. (2002), but was left in the centrifugation tube to prevent any possible loss of curd during transfer of the centrifuged curd pellet. The correlation between Yc based on wet curd vs. dry curd is presented in Figure 1; the regression coefficient was 0.96.

Statistical Analysis

The dependent variables were SCC, NAGase, milk yield, fat, protein, lactose, CN, whey proteins, albumin,

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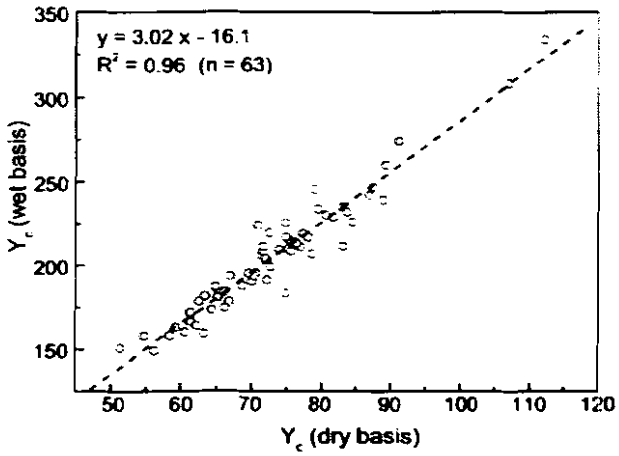

Figure 1. Comparison of curd yield (Yc) on dry basis vs. wet basis (g/L).

p-p, $[Ca^{2+}]$, a_{Ca}^{2+}, PL, PA, Yc, and Tc. Data were analyzed with the JMP statistical software (SAS, 2002) under a randomized block design in which goats served as blocks. Within each block, there were 2 levels of bacteriological status, as follows:

$$Y_{ij} = \mu + G_i + B_j + e_{ij}$$

where Y_{ij} = dependent variable, μ = overall mean, G_i = goat, where i = 1 to 25, B_j = bacteriological status where i = 1 (infected) or 2 (uninfected), and e_{ij} = error term (experimental variation between udder halves within a goat).

No significant difference in SCC was found between the different CNS species, which was consistent with previous results (Leitner et al., 2004, accepted); therefore, the analysis was completed over species.

RESULTS

The pathogens causing the udder infections were various species of CNS: *S. epidermidis* (n = 11), *Staphylococcus simulans* (n = 6), *S. caprae* (n = 2), *Staphylococcus chromogenes* (n = 3), and *Staphylococcus xylosus* (n = 3). The bacterial species isolated from any given gland was identical at each sampling. No clinical abnormalities were visible or palpable in >80% of the goats tested.

Milk yield of the infected halves (0.69 kg/milking) was significantly lower ($P < 0.0001$) than that of the uninfected halves (0.98 kg/milking) (Table 1). The measured indications of infection response—SCC and NAGase activity—were significantly higher in the infected halves than in the uninfected ones.

Table 1. Effects of mammary gland infection on milk production and composition using half-udder design with 25 Israeli dairy goats tested 2 or 3 times at 10- to 20-d intervals.

	Bacteriological status		Effect	
Parameter	Uninfected	Infected	Infection	Goat
Milk, kg/milking	0.96 ± 0.04	0.69 ± 0.04	<0.0001	<0.0001
SCC ± SE (×10³)	417 ± 72	1750 ± 197	<0.0001	0.07
NAGase[1]	13.6 ± 2.7	37.9 ± 4.5	0.05	NS
Fat, g/L	38.9 ± 1.1	38.8 ± 1.2	NS	0.0002
Protein, g/L	34.2 ± 0.5	35.0 ± 0.5	0.07	<0.0001
Lactose, g/L	47.0 ± 1.0	41.7 ± 1.3	0.004	0.004
Whey, g/L	6.1 ± 0.3	6.8 ± 0.4	<0.0001	<0.0001
Casein, mg/mL	28.1 ± 0.7	28.2 ± 0.8	NS	<0.0001
Albumin, μ/mL	279.9 ± 22.2	471.8 ± 49.8	0.003	0.04

[1]A value of 100 corresponds to a product release of about 5 μmol/L per min at 25-C. [Au: What is level of NS?]

Lactose concentration in the infected glands was significantly lower ($P < 0.004$) than that in uninfected glands. The concentration of fat did not differ between the uninfected and infected halves. Protein concentration tended to be higher in the infected glands ($P < 0.07$). Casein concentration did not differ, whereas whey protein and albumin concentrations were significantly higher in the infected glands than in the uninfected glands. The goat effect on these variables was significant (Table 1).

Plasminogen activator and PL activities were significantly higher in the infected glands than in the uninfected ones (Table 2). Plasminogen activity was very low to undetectable; therefore, these data are not presented. Free (ionized) calcium did not differ, whereas a_{Ca}^{2+} was significantly lower ($P < 0.002$) in the infected glands vs. the uninfected glands. Concentration of p-p was 1.5 times higher ($P < 0.0005$) in the infected glands than in the uninfected ones (Table 2). The goat effect was significant for a_{Ca}^{2+} and p-p and insignificant for $[Ca^{2+}]$.

Table 2. Effects of mammary gland infection on plasmin (PL), plasminogen activator (PA), calcium activity (a_{Ca}^{2+}), free (ionized) calcium ($[Ca^{2+}]$), proteose peptones (p-p), curd yield (Yc), and clotting time (Tc). A half-udder experimental design was utilized with 25 Israeli dairy goats.

	Bacteriological status		Effect	
Parameter	Uninfected	Infected	Infection	Goat
PL, unit[1]/mL	20.32 ± 2.4	39.81 ± 6.1	0.0003	0.005
PA, unit[1]/mL	3376 ± 404.1	4334 ± 565.5	0.05	0.002
a_{Ca}^{2+}, mmol	1.89 ± 0.1	1.62 ± 0.1	0.002	<0.0001
$[Ca^{2+}]$, mmol	4.80 ± 0.4	5.05 ± 0.3	NS	NS
p-p, mg/mL	0.35 ± 0.05	0.53 ± 0.05	0.0005	0.0002
Yc, g/L	231.6 ± 2.9	207.6 ± 2.7	<0.001	<0.0001
Tc, s	167 ± 16.6	295 ± 43.4	<0.02	<0.08

[1]Unit = activity unit; 1 unit is the amount of PL that produces a change in absorbance of 0.1 at 405 nm in 60 min. [Au: What is level of NS?]

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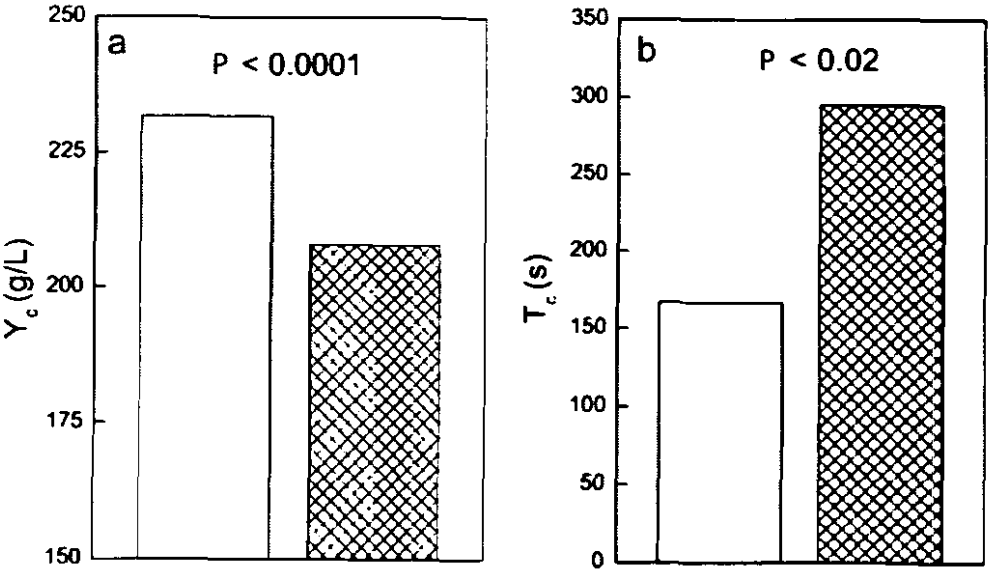

Figure 2. Effect of subclinical mastitis on a) curd yield (Yc) and b) clotting time (Tc) in milk of infected vs. uninfected udder halves. Open bars = uninfected glands; hatched bars = infected glands.

Curd yield was significantly lower ($P < 0.0001$) in the infected halves, and there was a significant goat effect ($P < 0.0001$). Clotting time was significantly longer ($P < 0.02$) in the infected halves than in the uninfected ones, with a relatively small goat effect ($P < 0.08$) (Figure 2).

DISCUSSION

Model and Individual Animal Effect

Use of the half udder as the experimental unit has been found to enable quantification of the negative effect of SM on milk yield with high statistical reliability, even for a relatively small data set of 20 to 40 animals. This finding is consistent with that of a recent study on sheep (Leitner et al., 2004). The half-udder model is an effective tool for isolating the experimental effect from masking effects. An alternative approach based on conventional whole-udder sampling would require a data set of the order of 100 animals to account for the large and significant individual variations in the sheep or goat effect on most of the indices measured in these studies. These significant sheep or goat effects most likely reflect the diversity of genetic (breed) sources in the Israeli flocks, and they are further complicated by the effects of factors such as farm management, environmental conditions, age, and stage of lactation. Obviously, variations caused by all of these factors are neutralized when the unit of comparison is 2 udders of the same animal.

Infection and Milk Yield

Various CNS bacteria are the most abundantly occurring in isolates associated with SM in goat herds in a number of countries (Kalogridou-Vassiliadou, 1991; Contreras et al., 1997; 1999; Haenlein, 2002). CNSs are not considered as major pathogenic bacteria, and their occurrence is usually ignored by farmers and veterinarians (Leitner et al., 2004a). However, in the present study, CNS infection induced the inflammatory response, reflected in the high SCC, which is consistent with previous findings in goats and sheep (Lerondelle et al., 1992; Contreras et al., 1999; Haenlein, 2002; Leitner et al., 2003). The inflammatory response was associated with a marked reduction in milk yield in the infected gland compared with that of the uninfected one, which is consistent with earlier results in sheep (Leitner et al., 2003, 2004). In sheep with both glands infected, the reduction in milk yield was significant, whereas when only one gland was infected, the contralateral gland compensated for about 80% of the reduction. Thus, although the point has not yet been tested, we cannot rule out the possibility that in goats too, compensation in the uninfected gland mitigates the effect on milk yield as measured on a whole-animal basis when only one gland is infected. Nevertheless, the extensive survey of milk records of goat farms in France by Baudry et al. (1997) leaves no doubt that increased SCC associated with IMI reduced milk yield in comparison with farms with low SCC.

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a_{Ca}^{2+} as a Measure of CN Degradation

Silanikove et al. (2003) demonstrated a negative linear relationship between CN concentrations in milk of humans, goats, cows, sheep, and mice, on one hand, and a_{Ca}^{2+} on the other, a finding that is consistent with the fact that CN are powerful Ca chelators. In the present study, a_{Ca}^{2+} was negatively related to measures of proteolysis (p-p), which was consistent with similar findings in sheep (Leitner et al., 2004). The association between CN degradation and the reduction in a_{Ca}^{2+} may be related to the exposure of phosphoserine groups that are hidden within the casein micelles because these molecules are responsible for the Ca-chelating properties of CN. Casein degradation occurs in the gland during the intervals between milkings (Le Roux et al., 1995; Urech et al., 1999). Thus, the differences in a_{Ca}^{2+} between the infected and uninfected glands may represent the additional CN degradation in the infected glands. The present results further support the conclusion that measurement of a_{Ca}^{2+}, which is rapid and cheap, appears to be a valuable tool for monitoring the extent of CN degradation under various conditions.

Yc and Milk Tc

Curd yield was lower from the infected halves than from the uninfected ones, although the CN contents were almost equal in the 2 glands. Negative effects of mastitis on CN content and cheese yield were also reported for cow milk (Auldist and Hubble, 1998). Thus, our data suggest that knowledge of the gross CN content in the milk is insufficient for predicting Yc, probably because of modifications in the CN micelles or in the various CN micelle components that are more detrimental to curd formation than they are to the CN concentration itself. The primary enzymatic coagulation is based on the action of rennin on κ-CN, which, thereafter, exposes hydrophobic sites on the CN micelle, thus making it available for the secondary aggregation reaction (Ernstrom and Wong, 1974). However, the effect of rennet and, therefore, the coagulation process may be impeded by only partial hydrolysis of κ-CN and more pronounced hydrolysis of the other caseins by enzymes such as PL and cathepsin (Srinivasan and Lucey, 2002; Moussaoui et al., 2003). Thus, the conversion of CN to whey components (p-p) by PL may partially explain the reduction in Yc. In support of this hypothesis, a significant positive correlation was observed between the PL and PA activities, on one hand, and the rennet Tc, on the other hand, which is consistent with similar interactions found in late-lactating goats (Fantuz et al., 2001) and in subclinically infected sheep (Leitner et al., 2004). The changes in p-p concentration and a_{Ca}^{2+} in the infected glands suggest that CN was modified by the release of certain peptides or because of a change in the CN micelle compaction that was caused by changes in a_{Ca}^{2+} (Leitner et al., 2004) and that this hampered the coagulum formation. The combination of higher PL activity in the infected gland and the long interval of about 12 h between the evening and morning milkings resulted in a correspondingly and considerably higher proteolysis of CN by PL, because of the extended exposure of CN to its action, as was found elsewhere for added PL in vitro (Srinivasan and Lucey, 2002).

Interrelationships Between Milk Yield and Composition in Subclinically Mastitic Goats

The present finding of an upregulation in the activity of the PL system in glands infected with SM is consistent with previous findings in dairy cows (Schaar and Funke, 1986; Auldist et al., 1996; Urech et al., 1999) and dairy sheep (Leitner et al., 2004). Higher protein and fat concentrations were found in infected glands than in uninfected ones (Leitner et al., 2003, 2004); at the same time, milk volume decreased, suggesting that this response is related to a mild increase in PL activity (30 to 50%) over the basal level. Under such conditions, plasmin-induced hydrolysis of CN liberates a peptide from β-CN (β-CN 1-28), which in turn down-regulates milk secretion in cows and goats; its activity was correlated with its ability to block potassium channels in the apical membranes of mammary epithelia (Silanikove et al., 2000). However, in some individual cases, the protein and fat concentrations were found to be lower in infected glands than in uninfected ones. Such a response was observed when the increase in PL activity was large (2-fold or more), as is the case during milk stasis (Shamay et al., 2002, 2003). It has been shown that CN hydrolysis under high PL activity induces rapid drying-off of mammary secretions in goats (Shamay et al., 2002) and cows (Shamay et al., 2003).

In the present study, despite the doubled PL activity, the reduction in milk yield more or less matched the reductions in protein and fat secretion, so that overall there was no net change in protein and fat concentrations. However, as discussed previously, there is compelling evidence that the CN was degraded and modified in the infected gland. The marked reduction in lactose concentration resembled the response in sheep and cows under high PL activity. Thus, the degree of PL activation determines not only the reduction in milk volume, but also the changes in the secretion of organic components and, consequently, milk composition and Yc, probably because certain structural modifications in the molecule affect its ability to aggregate, owing to the proteolytic action of enzymes on the CN micelle.

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Comparisons Between Goats and Sheep

Application of the half-gland model to the same set of measurements performed with similar methodologies in sheep and goats provides us with a unique opportunity to compare the responses of the 2 species to subclinical IMI with CNS.

The SCC levels in uninfected glands of goats and sheep (around 200,000 cells/mL) were higher than those reported for uninfected cows (Maisi et al., 1987; Fthenakis et al., 1991; Baro et al., 1994; Gonzalo et al., 1994; Gonzalez-Rodriguez et al., 1995; Paape and Capuco, 1997). In both goats (Leitner et al., accepted) and sheep (Leitner et al., 2004), CNS IMI increased SCC to $>10^6$ cells/mL, suggesting that diapedesis in response to the latter in goats and sheep is more acute than in cows. Whether this more severe influx of leucocytes to the mammary gland is associated with improved antibacterial defense capacity is a question that remains to be answered.

In sheep, the reduction of milk yield in the infected glands was 53% (Gonzalo et al., 1994), which is considerably higher than the 30% reduction in milk yield in the infected glands of goats, which was found in the present study. It is consistent with these differences that the reduction of lactose concentration in the infected glands was 25% compared with that in the uninfected glands, i.e., twice the reduction of 11% found in goats in the present study. It may be concluded that the much higher reduction in lactose secretion in the infected glands of sheep (65%) than in those of goats (37.5%) is the main reason for the finding that the reduction in milk volume in the infected glands was greater in sheep than in goats.

In both goats and sheep, the reduction in whey protein secretion was less than the reduction in milk yield, because of the increased protein concentration in the infected glands of both species. The gross CN concentration in goat milk (28 g/L) resembles that of cow milk and is much lower than that in sheep milk (40 to 46 g/L). Thus, the p-p concentration in uninfected glands in goats is consistent with the lower CN concentration. Moreover, the increase of p-p in the infected gland in response to doubled PL activity was still much lower than the corresponding figure in sheep, and the reduction in a_{Ca}^{2+} in the infected glands was lower in goats than in sheep.

It is noteworthy that the PL activity found in the present study in uninfected glands (Figure 3a) was essentially similar to that found in goats by Baldi et al. (2002), who used the same methodology. In both studies, PLG activity was close to zero (Figure 3b), which may be explained by the unusually high PA activity (Figure 3c). The PA activity found in the present study

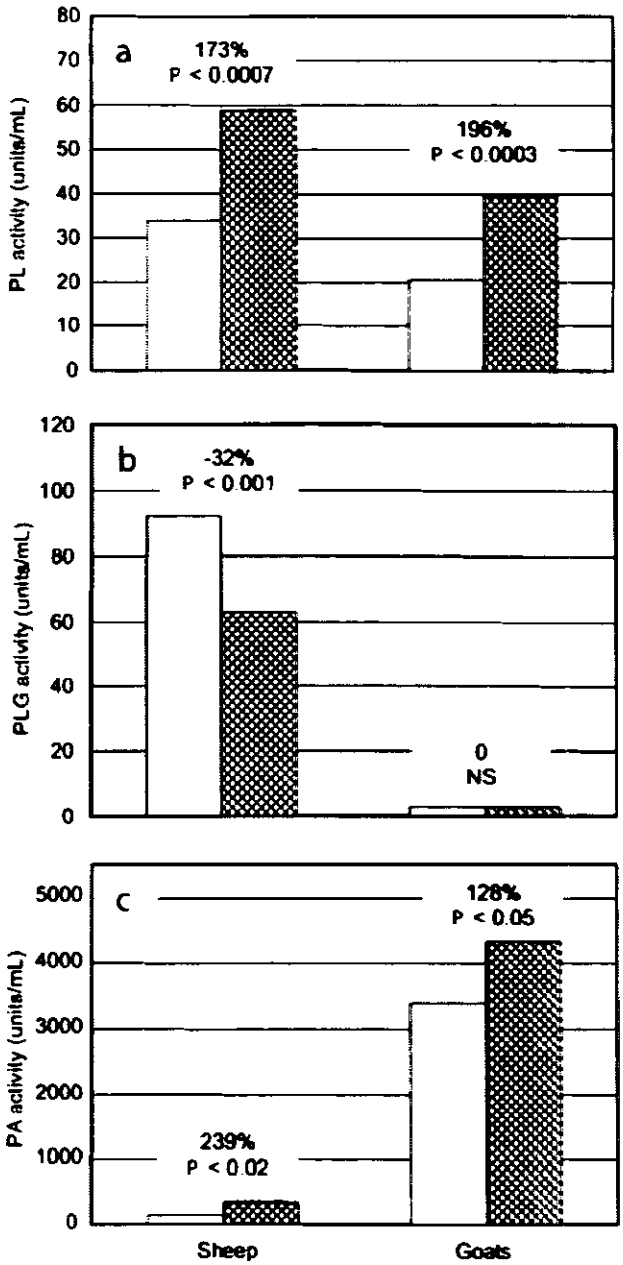

Figure 3. a) Plasmin (PL), b) plasminogen (PLG), and c) and plasminogen activator (PA) activities in milk from uninfected vs. infected udder halves in sheep and goats. Open bars = uninfected glands; hatched bars = infected glands

was even higher than that reported by Baldi et al., possibly because the PA was determined in whole skim milk, whereas Baldi et al. (2002) determined it in redissolved CN. When the PLG activity is added to that of PL to obtain the total PA-derived activity it becomes

clear that the latter is considerably higher in sheep than in goats. The initial level of the PLG pool in the goat gland ought to be much lower than that in the sheep gland, which may be an additional reason for the apparently rapid disappearance of PLG from the goat mammary gland.

It has been suggested that regulation of PA activity serves as a bridge between systemic hormonal influences and the local regulatory system (Silanikove et al., 2000). In the organ culture of the mouse mammary gland, hormones that fostered involution induced PA synthesis, whereas hormones that promoted lactation repressed PA secretion (Ossowski et al., 1979). The treatments of cows (Politis, 1996) and sheep (Baldi et al., 1997) with bovine somatotrophin increased milk yield and reduced the conversion of PLG to PL. On the other hand, stress, stress hormones, and estrogen, which induce down-regulation of milk yield, increased PL activity in milk (Athie et al., 1997; Silanikove et al., 2000). The high basal level of PA in goats may make the system irresponsive to systemic effects. Consistent with this suggestion, treating goats with somatotrophin did not affect the PA system (Baldi et al., 2002), whereas treating goats with adrenocorticotrophin and dexamethsone did not reduce their milk yield (Shamay et al., 2000a), as it did in the case of dairy cows (Shamay et al., 2000b).

CONCLUSIONS

The findings of the present study highlight the economic loss that can be attributed to IMI caused by CNS; this was clearly demonstrated by using the half-udder model. In goats, as in sheep, infection decreased Yc and increased curd Tc, and these changes were reflected in increased CN degradation, increased CN degradation products (p-p), and decreased a_{Ca}^{2+}. However, the higher CN content and higher PL activity in sheep than in goats results in a higher output of CN degradation products, including factors that down-regulate milk secretion. This accounts for the stronger effect on milk yield in sheep than in goats. This scenario suggests that in terms of milk yield, sheep are more vulnerable than goats to subclinical infections, though definite conclusions should await the accumulation of additional independent data. The trends in the responses of PA and PL activities to SM are similar in goats and sheep. The unusually high basal PA activity in goats results in a lack of PLG in their milk. Consequently, our results suggest that the PL system functions at a lower rate in goats than in sheep and that its response to external factors, such as infection, that augment its activity in other species is more attenuated in goats.

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