Deliverable Factsheet

Date: March 2016

Deliverable No.	D1.4
Working Package	WP1
Partner responsible	CSIC
Other partners participating	DAPVET
Nature	Report
Dissemination level	PU=Public
Delivery date according to DoW	Month 55
Actual delivery date	April 2016
Finalization date	April 2016
Relevant Tasks:	Task 1.4: On-farm participatory research Task 2.3 Genetic and phenotypic characterisation of dairy goat breeds which are perceived to be adapted to low input conventional production systems Task 2.3 Genetic and phenotypic characterisation of dairy goat breeds which are perceived to be adapted to low input conventional production systems Task 3.1: Development of novel and underutilized feed resources including by-products from processing of renewable raw materials

Brief description of the Deliverable Discussion of the innovations assessed in SOLID with regards to feeding and health in dairy goats
Target audience(s) Researchers, farmers and extension services

Executive Summary

The SOLID project (Sustainable Organic Low-Input Dairying) carried out research to improve the sustainability of low-input/organic dairy systems in different ways. This report is part of a series of three that summarise recommendations arising from participatory research with innovative strategies involving farmers, supply chain partners and researchers in the SOLID project.

Dairy goat farming in Europe is characterised by large diversity in production systems due to the wide range of feed resources and feeding systems. Factors such as geography and climatic conditions, different breeds of dairy goat population and the various marketing circuits and transformation contribute to a large variety of products. Farmers are continuously facing challenges that require adaptation and innovation to keep farms competitive under the different scenarios.

This document summarises the most recent work, conducted in the participatory research within the SOLID project, which addressed areas that represent major challenges in practice for both organic and low input production systems . Over the course of the different workshops held with dairy goats farmers in Spain and Greece as part of the participatory research activities in SOLID, two main areas of work were identified as needing more research effort. These two main areas were explored using designated experiments: i) and ii) feed supply strategies and iii) genetic resources in relation to health and productivity.

i) Ensiling was tested as a strategy to preserve and supply tomato and olive oil by-products to lactating goats in South Spain. The results showed that the use of by-products in dairy goats rations is well justified considering environmental, ethical and economic reasons, and therefore should be promoted. However, the limitations (variability in supply and feeding values, logistics, hygiene, product quality, economics etc.) must also be considered. Research can help in developing best practises in the use of by-products. In the particular case of agro-industrial by-products in Southern Europe, they can provide a range of nutrient resources, which have potential to be used as replacement of a range of conventional feeds. They vary widely in their nutritional value and therefore their use in diet formulation can be challenging. The high moisture content represents the main limitation for a successful use of some by-products by the feeding industry. A trial was conducted in a commercial farm in South Spain to assess the effect of replacing conventional medium-quality forage with two selected silages made using olive oil and tomato by-products. The results showed that ensiling tomato and olive oil derived by-products represent a valid strategy to maintain their nutritive value and ensure supply of these by-products throughout the year. Specifically silages made with tomato and olive by-products may replace medium quality forage (i.e. oat hay) in dairy goat feeding without compromising milk yield, provided that the farm is within a 50 km radius from the site of production of the by-product. Further to the nutritional attributes, the environmental benefits of using such by-products in dairy goats feeding have been shown by using LCA. The outcome suggests that the new dietary strategies tested offer promising overall GHG reductions, in relation to N_2O emissions (from

feed production stages) and enteric CH_4 (in the case of tomato wastes) without productivity being compromised. These findings must be taken with caution as food industry by-products could have alternative and competing uses, other than feed, such as energy production and soil organic amendment. Assumptions made and categories evaluated should be considered carefully in a decision making process.

ii) The potential use of irrigated sown pasture as an additional feeding strategy in semi-intensive dairy goat production systems was explored. Considering the cost of feeding indoors purchased feedstuffs and the particular climatic conditions in the Mediterranean, establishing and maintaining irrigated pastures for dairy goat production systems was seen as a challenge. The notion was that if such a practice was proven beneficial for the farm then it could be adopted by many other dairy goat farms that currently rely mainly on grazing communal areas that are located at significant distances from their farms. The latter is a significant cost in terms of required personnel but also is limited to certain times of the year due to the scarcity of available grazing during the summer and early autumn months. The study provided data regarding pasture management in relation to dairy goat performance in terms of milk yield and milk quality that can be used to make decisions about the feeding management of dairy goats.

iii) The data collected for health and welfare of three different dairy goats breeds in Greece filled a critical knowledge gap in terms of providing basic information on the productivity, reproductive performance, health and welfare and milk quality within low input Greek dairy goat production systems. The reduction in productivity due to infestation and subclinical mastitis was quantified for the first time for this system.
Distinct differences were identified between the different dairy goat breeds studied herein. One foreign breed, the Damascus dairy goat, appeared to be well adapted to the specific requirements of Southern European low input systems.

Overall the experience in participatory research was rather positive for both scientists and farmers. With the scientist acting as facilitator, farmers and scientists closely worked together from initial design of the research project to data gathering, analysis, final conclusions, and follow-up actions. It is clear that new information, technologies and concepts may be better communicated to farmers through this approach.

Potential Stakeholder impact(s)

The research presented in this deliverable provides further evidence of the potential of using agro-industrial by-products in small ruminant feeding. The particular case of ensiling high moisture by-products will enhance wider use of this material in the areas where the industry provides such opportunity. Also, the environmental benefit in terms of greenhouse gas emissions may encourage local administration to promote the use of this technology.

Important information has been also obtained to guide the discussion on adaptation of breeds (local and imported) of dairy goats to low input systems and that health issues need to be addressed in these systems. This document provides better insight in some management actions that need to be considered to improve dairy goats welfare under these systems.

Interactions with other WPs Deliverables / joint outputs			
WP no.	Relevant tasks	Partner(s) involved	Context of interaction
3	3.1	MTT, ABER, CSIC, INCDBNA, ORC	Deliverable 3.1. Desk-top review of novel feeds for inclusion in organic and low-input dairy production included section on agroforestry.
3	3.1	CSIC, MTT, INCDBNA, ORC	Deliverable 3.3 Potential of novel feed resources for organic and low-input dairy production
2	2.3.	DAPVET	Deliverable 2.5 Adaptation of dairy cattle and goat breeds to organic and low input production systems]

Project no. 266367

Project acronym: **SOLID**

Project title:
Sustainable Organic and Low Input Dairying

Collaborative Project

SEVENTH FRAMEWORK PROGRAMME
KBBE.2010.1.2-02
Sustainable organic and low-input dairy production

Title of Deliverable:

D 1.4 Recommendations on innovative strategies related to nutrition, health and welfare of small ruminants

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Due date of delivery: **Month 55**
Actual submission date**: Month 60**

Start date of project: 1st April 2011 Duration: 60 months
Work package: 1
Work package Leader: Susanne Padel
Version: Final

Dissemination level: PU=Public

Acknowledgements

We sincerely thank all the farmers who participated in the research trials and case studies as well as all partners in WP1 for their co-operation and support provided over the five years of this project. This publication was generated as part of the SOLID Project (http://www.solidairy.eu), with financial support from the European Community under the 7th Framework Programme (Agreement No. 266367). The publication reflects the views of the authors and not those of the European Community, which is not to be held liable for any use that may be made of the information contained herein.

Contents

1. Introduction, participatory research

The participatory or farmer-led research in the SOLID project (Sustainable Organic Low-Input Dairying) was aimed at promoting innovation through actively involving stakeholders (i.e. organic or low-input dairy farmers, farmer groups and farm advisors) and researchers. To identity research priorities, sustainability assessments were carried out on more than 100 (organic/low-input) dairy cow or dairy goat farms in nine countries across Europe. The results were discussed with farmers and stakeholders in national workshops where specific research topics were identified (see Leach et al. 2013 for further details).

In total eighteen on-farm participatory trials, discussion groups or case-studies were conducted in the UK, DK, FI, RO, ES, GR, AT and IT covering aspects related to feeding and forage, use of natural resources, environmental impact and animal management and health. This work was co-ordinated by the Organic Research Centre as part of the SOLID project. This deliverable is one of three that are resulting from this work on innovation through stakeholder engagement and participatory research (WP1) and presents recommendations on innovative strategies related to nutrition, health and welfare of small ruminants. The results and recommendations of other farmer-led studies are presented by Zaralis et al., (2016) and Vaarst et al., (2016).

Dairy goat farming in Europe is characterised by large diversity in production systems due to the wide range of feed resources and feeding systems. Factors such as geography and climatic conditions, different breeds of dairy goat population and the various marketing circuits and transformation contribute to a large variety of products. Farmers are continuously facing challenges that require adaptation and innovation to keep farms competitive under the different scenarios. Some difficulties are common to most sheep and goat production systems in Europe:

I. Sheep and goat farming is very labour-intensive and it requires specific skills. The sector is being hampered by a lack of technical services and training, and those result in very varied levels of productivity;

II. Incomes are among the lowest in the agricultural industry and depend heavily on public support (subsidies), with inadequate farm-gate prices and poor monetisation of by-products (wool, pelts, offal, etc.);

III. Increasing costs, particularly for fuel, electricity and feed, together with the electronic identification system, introduced in 2010, constitute additional costs perceived as being too high in the current situation;

IV. Sheep and goat farmers are older than farmers in other sectors, sometimes reluctant to make changes and young people are not interested in the business;

To achieve the ambitious objective of maintaining the competitiveness of dairy goat sector, more innovation and technology is required. However, innovation cannot be based on the old top–down model but on partnership and interaction among all stakeholders and trans disciplinary approaches have to be enhanced (Dubeuf, 2011, Escareño et al. 2013). The latest innovations available in the ruminant sector with regards to feeding, reproduction, genetic characterisation of local breeds, flock management, and parasite control, among others have been tested in more depth in the cattle sector but no so much in sheep and goats (Dubeuf, 2014).

The results included in this deliverable are part of the exercise to establish a network of participatory research farmers, advisors and scientists within SOLID, involving the farmers/farm managers and their processor through on farm experiments and/or monitoring of novel strategies. The emphasis of this task was working with producers to support innovation on their holdings through participatory engagement in the development, implementation and analysis of relevant, producer-led research projects. Time was reserved at the project meetings to co-ordinate among the participating project partners. Depending on the research question, farmers would be trained in specific methods where appropriate.

The topics to be investigated were open and to be identified by the industry partners in previous projects tasks (1.2 and 1.3). Research priorities expressed by some stakeholder partners suggest that the link between animal nutrition and health and impact of feeding on milk quality were topics likely to be covered. The main emphasis is to investigate meaningful innovative approaches that can be undertaken on one or more farms, with the outcome being compared against standard industry data, or as on-farm experiments. Given the participatory nature of the work it was not possible to fully pre-determine the topics and therefore it was expected that projects would differ across countries, ruminant species and geographic regions.

This deliverable summarises the most recent work, conducted in the SOLID project, which addressed some of the challenges encountered specifically in dairy goat production systems. As a result of the national workshops held in Spain and Greece with dairy goat farmers and under the umbrella of the SOLID project objectives, two main areas were explored using designated experiments: i) feed supply strategies and ii) genetic resources in relation to health and productivity.

1.1. Feed supply strategies

The quantity and quality of available feed resources is a key determinant of total system output, and overall profitability. Low input dairy systems have uniqueness in their high reliance on internal forage resources which will at least temporarily limit system productivity and inevitably may require production goals to be adjusted (Schiere et al., 1999, Zollitsch et al., 2004). This together with increased volatility in feed prices, highlights the need for a broadening of feed resources and the utilization of novel feed components that are currently under-utilized. In addition, strategies which optimise the management of on-farm feed resources can reduce the risk inherent to organic and low input feed supply chains (e.g. seasonality of pasture/ forage production). Therefore, there is a need to enhance the multi-functionality of organic and low input dairy production systems, for example using the following approaches:

i) Increasing the accessibility of feed resources to dairy farmers (**strategy 1, section 2.1.**). Studies need to identify the availability and quantify the nutritional value of unconventional feed components, especially by-products from food and non-food processing (Yáñez-Ruiz and Molina Alcaide, 2007; 2008, Yáñez-Ruiz et al., 2009). Since the nutrition of the animal is a major factor influencing milk quality and the high level of forage use in organic and low-input dairy production systems is beneficial to improving the “healthiness” of the milk fatty acid profile in goat milk (Chilliard and Ferlay, 2004; Dewhurst et al., 2006), it is important to assess the impact of these novels feeds on milk quality in the context of adapted dairy breeds to low-input/organic systems.

ii) Developing tools with the potential to optimise the management of internal resources (**strategy 2, section 2.2.**) and specifically, pastoral areas.
The gradual intensification of the dairy goat farms and the increased reliance to external feed inputs that has occurred over the last decades in Europe has made farmers less aware of the importance of proper management of available pastures. The latter is likely to affect the sustainability of farms by increasing their dependence on purchased feeds when grass production in the farm is not optimal. Knowledge of grazing systems it is necessary to assess their potential and what actions can be taken to improve them through structural or management interventions, on farm level, which can increase farmers’ income and enhance the viability of their farms. Also, such knowledge could function as starting point for the development of alternative feed resources to limit the reliance on external feed inputs (Ruiz et al. 2009, Gaspar, et. al 2011)

1.2. Genetic resources and health

Small ruminants play a key role in overall milk production in several European regions, but scientific information regarding the adaptation of dairy goats to low input systems is lacking. Most goat breeds or genotypes, including autochthonous breeds, are thought to be “adapted” to low input environments. However, there is a lack of scientific evidence regarding the interaction between different goat genotypes with their system of production in terms of their performance and health, particularly udder health.

Subclinical mastitis (SCM) is one of the most challenging diseases in dairy goat herds because it has been linked to production loss, downgrading of milk quality and hygiene, increased replacement cost, and considerable veterinary expenses (Koop et al., 2010). Several environmental and infectious pathogens have been isolated from SCM cases in goats reared under various systems. *Coagulase-negative staphylococci* and *Staphylococcus aureus* are frequently isolated from cases of SCM, whereas Streptococcus spp., Pseudomonas aeruginosa, Enterobacteriaceae, Mycoplasma spp., and other pathogens occur at lower frequencies (Contreras et al., 2007, Gelasakis et al. 2016). The frequency of isolation of different pathogens from goat herds is strongly related to the herds’ overall hygiene status and their general management schemes (McDougall et al., 2002). Regardless of the implemented management system, these practices seem to play a crucial role in the environmental contamination with udder pathogens and the establishment of IMI. The most prevalent production system in Mediterranean areas is the low-input, semi-extensive, pastoral system, with goats grazing throughout the year in shrublands and woodlands on semi-mountainous and mountainous areas (Arsenos et al., 2014). The produced milk is often locally used by the farmers for cheese production without pasteurization. Hence, when present in raw milk, intra-mammary pathogens of public health significance can end up in the final product. This is particularly important in the case of soft cheeses where the absence of ripening or the insufficient degree of ripening may render them unsafe for the consumer. Even if milk is pasteurized, the risk of cross contamination during production and handling, as well as the risk from thermostable staphylococcal enterotoxins which can persist in the processed products still exists (Contreras et al., 2003). In the majority of cases, low-input management schemes in dairy goat herds, which are considered compatible with the principles of organic farming, have not been assessed in terms of goats' udder health status, their productivity, and the hygiene status of the produced milk. Also, the interaction among these factors remains unexplored. The epidemiology of SCM in low-input dairy goat herds and data regarding the most significant pathogens associated with its incidence are rather scarce (Gelasakis et al. 2016). Also, the effect of SCM on milk yield in goats reared under these systems remains unknown. The work conducted in SOLID in WP2 assessed the major pathogens associated with SCM, calculated the incidence of SCM during the milking period, and estimated the effect of SCM on milk yield of goats reared under low-input management schemes (Gelasakis et al. 2016). This is presented in **section 2.3.**

2. Innovative strategies

This report presents three on-farm experiments with dairy goats that were conducted under the SOLID project. The first two (2.1. and 2.2.) deal with feeding management while the third is related to animals' health (2.3.).

2.1. The use of silage made with local agro-industrial by-products in dairy goats feeding

2.1.1. Context

The price of conserved forages for animal feed has risen steadily in recent years leading to increased cost of animal production. Thus, finding substitutes for this type of feed has become a priority for livestock producers. In this context, crop residues, agricultural wastes and agro-industrial by-products of local origin are gaining renewed interest as alternatives to reduce feeding costs of ruminants. One important source of agricultural waste and agro-industrial by-products in Mediterranean countries is greenhouse horticulture, with Spain being one of the main producers in this area (MARM 2011). A significant proportion (up to 15%) of fruit and vegetable production is discarded because the appearance of the fruits does not meet the grading standard for sale in the fresh market or for processing (Wadhwa & Bakshi 2013). Moreover, the storage of these fruits, which are easily spoiled, generates economic costs and contributes further to environmental pollution. Several studies (Fondevila et al. 1994; Denek & Can 2006; Aghajanzadeh-Golshani et al. 2010) have investigated the nutritive value of by-products from different origins as feed for ruminants, but mainly in sheep; however, very scarce information is available in dairy goat production systems.

2.1.2. Initial screening of by-products

Seven types of by-products from different industries were collected and processed for determination of chemical composition (Table 1) following the methodology established in our lab (Martín-García et al., 2004). In addition, a sequence of *in vitro* gas production trials were conducted to evaluate the ruminal fermentability of the by-products *per se*. A batch culture of mixed rumen microorganisms was used as described in Martínez-Fernández et al. (2013). Results showed variability in the chemical composition reflecting the different nature of the resources. Some by-products had high protein contents (i.e. cauliflower fruit, orange leaves), others medium (tomato and orange fruit wastes) and some rather low (olive pulp and leaves) with high levels of fibre components. The values observed were in agreement with previous observations (Molina-Alcaide and Yáñez-Ruiz, 2008; Soto et al., 2012; Fondevila et al., 1994; Ventura et al., 2009). This first screening highlighted the differences in the potential of these by-products to replace more conventional feedstuffs, depending on their chemical composition. While some would be suitable as forage alternatives, others could potentially replace cereal grains in the diet of ruminants, however, due to variation in moisture content (Table 1) special attention should be paid for the inclusion of these by-products into the animal diets. This also indicates that research is needed for developing appropriate processing and storing methods to ensure sustained supply and feed security (Wadhwa and Bakshireveals, 2013) and represents one of the main challenges for efficient use of such material in practical feeding on farm.

Table 1. Characterization of a range of by-products from different origins.

	Origin	n	Dry matter, g/kg	In dry matter, g/kg OM	CP	NDF	ADF	Lignin	DM Digestibility*
Tomato fruit waste	Motril	11	61.5	899	103	191	139	49	910
Olive pulp	Granada	18	676	889	99	632	430	236	512
Olive leaves	Granada	16	515	819	74	418	282	167	544
Pomegranate pulp	Alicante	8	671	948	121	121	89	21	760
Orange fruit waste	Almeria	5	425	959	84	127	62	34	780
Mandarine waste	Almeria	5	501	960	62	154	65	38	720
Lemon waste	Almeria	5	488	958	73	97	70	41	831
Orange leaves fresh	Almeria	8	601	872	172	177	120	78	682
Orange leaves dried	Almeria	6	852	871	125	285	178	89	501
Cauliflower fruit	Alhama	4	522	870	255	212	145	101	812
Cauliflower leaves	Alhama	4	654	838	126	145	98	72	795
Cucumber waste	Motril	10	37.1	887	163	168	131	2.50	856
Tomato silage	Motril	3	521	888	119	516	234	121	751
Olive silage	Granada	3	575	873	88	390	240	145	590

*Ankom in vitro digestibly procedure (Martín-García et al., 2004)

2.1.3. Silage making

Based on the results obtained from the *in vitro* screening, together with previous observations at CSIC, a series of trials were conducted to optimize the process of ensiling some of the selected by-products and to ensure appropriate storage and supply to the farms throughout the year. The by-products that were selected for the trials were tomato fruit waste, olive pulp and olive leaves because these are quite abundant in south Spain; for example annual production of tomato fruit and olive by-products in Andalucíaare about 400,000 tonnes and 525,000 tonnes, respectively (MAGRAMA 2012). Tomato fruit waste is available throughout the year and the volume wasted depends upon changes in prices and oversupply of vegetables from North Africa. It is estimated that on average around 15 % of the production is wasted prior to reaching the consumption market. Olive cake and olive leaves are produced during December-March, with the quantity produced relatively constant from year to year. As stated above, for tomato fruit and olive cake the high moisture represents the main challenge as discussed in Deliverable 3.1. (Rinne et al., 2012).

The aim of the on-farm trials under the SOLID project was to develop silage-making techniques using the above described by-products. Dehydration increases cost, about 250 - 300 litres of fuel and 200 kWh of electricity are required to produce one ton of dry product (88 - 90% DM). Research has shown that the ensiling of by-products is the most suitable method of conservation for long period (Lien et al. 1994; Bouqué and Fiems 1988; Hadjipanayiotou 1993; 1994; Kayouli 1989; Kayouli et al. 1993; Kayouli and Lee 1998). The main advantages of these particular silages are:

- can be efficiently used for strategic off-season feeding
- means of increasing feed resource availability and form of insurance, especially for kidding dairy goats
- fed to reduce pressure grazing when required
- efficient supplement to grazing goats during the dry season
- inexpensive home-made feed resulting in the production of milk at lower cost
- improve palatability and reduce significantly toxic substances present in some fresh vegetables to safe level concentrations
- can provide a major diet source, as basal ration as well as a feed supplement for grazing animals.

In order to achieve a successful ensiling of these by-products, the following points were rigorously respected:

- Moisture content: ensiled material contained more than 50% moisture to allow for easy and tight compression on the ensiled materials in order to achieve better compacting and eliminate air. However, excessive moisture (i.e. more than 75%) can also be harmful, leading to an undesirable fermentation in later phases and produces sour silage, which reduces palatability and intake. Water can be added and/or wet and dry feeds can be mixed to get such moisture.
- Length of chopping: The finer the chopping, the better the compaction and therefore fermentation and storage will be more successful, due to the effective exclusion of air. Chopping in small pieces can be done by hand or with a stationary forage chopper.
- The time it takes to fill a silo: It is important to ensure rapid filling and sealing of the silo as slow filling or delayed covering can easily increase feed losses due to undesirable aerobic fermentation.
- Presence of adequate fermentable energy (naturally present or added): In silage fermentation it is critical to achieve a stable low pH at which biological activity virtually ceases. In this way, preservation is obtained whilst nutrient losses are minimised and adverse changes in the chemical composition of the material are avoided. The final pH of the

ensiled by-products depends largely on the carbohydrate contents in the original materials. For this reason, protein-rich feeds with low content of energy are very difficult to ensile successfully and should be mixed with easily fermentable energy-rich products, such as molasses, rejected bananas and root crops.

Figure 1. Making silage bale (by Pablo Rufino).

Figure 3. Detailed photo of tomato silage (by Ignacio Martin-García)

Two types of silages (treatments) were tested in the on-farm trials: i) tomato fruit + straw (80:20 fresh weight basis) + 0.5 % formic acid and ii) olive cake + olive leaves + barley grain (45:45:10 fresh weight basis). These proportions were selected based on previous observations from silage making screening trials undertaken at CSIC. The ingredients were weighed and thoroughly mixed in a feed mixer. The mix was then baled, individually wrapped with four to six layers of "bale wrap plastic" (25 micrometre stretch film). This was performed with a bale wrapper, using a bale handler with front-loader (**Figure 1**). The bales had dimensions of 1.5 m x 1.5 m x 1.5 m and weighed around 800 kg each. Bales were opened after 60 days and samples were taken for evaluation of nutritive value (chemical composition and the *in vitro* rumen fermentation). The results of the nutritive evaluation were extensively presented in the SOLID Deliverable 3.3. (Potential of novel feed resources for organic and low input dairy production). The results indicated that the replacement of up to 25% (DM) of a oat hay diet with tomato silage did not have any detrimental effect on rumen fermentation; thus, this diet (25% silage) was selected for further *in vivo* tests as described in deliverable 3.3 and for an additional on-farm trial as described in the section below.

2.1.4. Using silage including by-products in diary goats farm

This trial was conducted in a dairy goat farm located in Granada. The farmer was actively involved in the activities conducted by CABRANDALUCIA in relation to the SOLID project and participated in all workshops and seminars. The trial was designed to study the effect of replacing a proportion of oat hay in a standard diet used at the farm with silages made by either tomato wastes or olive by-products on feed intakes, milk yield and milk composition and rumen fermentation characteristics. The farm had 200 milking goats, and 60 were used for the experiment. Animals were randomly allocated into 12 groups of 5 goats with each group of goats housed in individual pens of 25m^2 (5 x 5 m) that provided free access to water.

Three experimental diets were formulated as follows:

a) A Total Mixed Ration (TMR) containing 40% oat hay, 20 % Alfalfa hay, 12 %, Barley grain, 16 % maize grain, 13% Soya, 6% Molasses and 2%, mineral-vitamin mix (Control diet TMR)

b) A TMR in which 25 % of the oat hay was replaced by Olive by-product Silage (Experimental diet OS)

c) A TMR in which 25 % of the oat hay was replaced by Tomato by-product Silage (Experimental diet TS).

All proportions are expressed in fresh matter. The amount of feed supplied to the animals was sufficient to allow daily milk production of up to 2 kg per goat. All rations were supplied twice a day.

<u>Experimental procedure</u>

Four groups of 5 goats were randomly assigned to one of the three experimental diets (TMR, OS and TS), resulting in 20 animals per diet. After a 28 day adaptation period to the corresponding experimental diet, the experiment started and total diet intakes in each group were recorded over a 7-day period for each group (n=4). Individual goat milk yield was monitored every two consecutive days and aliquots (5 %) collected for milk composition analysis.

The work involved also at least one visit per week to the farm to monitor the behavior of animals, to discuss with the farmer the experimental set up and the collection of feed and milk samples. The farmer visited our research facilities before the start of the trial to receive training on the preparation of the silage and the best way to handle the product once the bale was opened. Feeding silage to goats in south Spain is not a common practice since most of the forage used is dry conserved (alfalfa and oat hay or straw).

Table 2. Effect of replacing oat hay in total mix ration (TMR) on intake, milk yield and milk composition and on rumen fermentation pattern.

	TMR	OS	TS	SEM	*P value*
DMI, g/d	916a	1426b	1286b	106	0.021
Milk characteristics					
Milk production, g/d	1010^{a}	1285^{b}	1387^{b}	86.3	0.007
Fat, g/kg	58.4	54.6	60.3	0.26	0.153
CP, g/kg	40.2	36.8	34.4	1.75	0.134
Lactose, g/kg	46.5	45.3	47.2	0.06	0.602
Total solids, g/kg	154	145	150	0.04	0.185

*Composition TMR: Oat hay 40%, Alfalfa hay 20 %, Barley grain 12 %, maize grain 16 %, Soya 13 %, Molasses 6 %, mineral-vitamin mix 2 %. OS: olive oil by-products silage; TS: tomato silage.
Means with different superscripts letters in a row significantly differ ($P<0.05$)

<u>Results and discussion</u>

Feeding both TSD and OSD diets resulted in higher DMI and increased milk production, although milk composition was unaffected (**Table 2**). Molina-Alcaide et al. (2003) and Romero-Huelva et al. (2012) did not find differences in DMI and milk composition in goats offered feed blocks (FB) containing olive cake and tomato wastes. The higher DMI observed in this trial may have been due to improved palatability of the silages used, compared to FB.

The literature available on the suitability of tomato and olive by-products in dairy farming is still limited and always involves the inclusion of such by-products as part of silage type forage. Ensiled wet tomato pomace used as a supplement in Comisana dairy ewes' diet did not modify milk yield or its gross composition (Di Francia et al., 2004). Similarly Weiss et al. (1997) reported that tomato pomace ensiled together with corn plants (total concentration of tomato by-product of 12 % on a DM basis) fed to lactating cows for 60 days neither affect milk production (35.5 kg/day) nor milk composition (total fat and protein) as compared to corn silage diet. More recently, Abdollahzadeh et al. (2010) in study with dairy cows observed that replacement of alfalfa hay with tomato and apple pomace (50:50) silagedid not affect milk composition but did result in an significant increase in milk yield (19.9 vs 21.9 kg/day).

Based on these results it was apparent that tomato wastes and olive by-products silages as alternatives to hay in the diet of dairy goats can increase DMI and milk yield without compromising milk composition. These results were further evaluated in terms of the costs associated with the collection and processing of the by-products. For the economic evaluation it was assumed that the silage will be produced at the farm, which implies that the tomato or olive by-products would need to be transported at the farm in first place. To simplify the calculations, it was assumed equivalent nutritive values of the silage and oat hay (on a dry matter basis). Considering the costs of collection, transportation and silage making and an average price of oat hay in south Spain of 0.14 €/ kg, we estimated that the use of both by-products is justified for a maximum distance of 50 km between the production site of the by-product and the farm. An alternative to reduce transportation-associated costs is to centralize the collection and production of the silage for a number of farms at the production site (http://www.hortoinfo.es/index.php/noticias/1629-ejido-reciclaje-30-07). CSIC is currently working with local governments and vegetables industry to establish silage making facilities at the plants where the wastes are stored.

2.1.5. Environmental assessment of the use of silage made with by-products

As stated in the previous sections, the optimal use of these alternative resources as animal feed could be an effective measure to decrease production costs of dairy goat farms, thus enhancing their competitiveness, but also an opportunity to reduce the environmental issues associated to livestock products (e.g. cheese) and organic-waste accumulation.

The stakeholder involved in this participatory research was CABRANDALUCIA, the Federation of Dairy Goats Association in South Spain. The productivity results were presented in a joint workshop with farmers and retailers and a question aroused about the scientific evidence of providing environmental benefits by using by-products in animal feeding. The Federation encouraged us to explore the possibility of conducting an environmental assessment of the effect of replacing a conventional animal feed with the silages including by-products. As agro-industrial by-products might have other uses than animal feed (e.g. bioenergy), with different implications on climate regulation, both direct (GHG and soil carbon) and indirect (e.g. as ammonia), resource-use efficiency (e.g. land use and porous-media use) and soil quality (e.g. soil organic matter), it was decided that a life cycle assessment was the most adequate approach to conduct the environmental assessment. Provided that farm income in the goat sector in the European Union (EU) is strongly influenced by specific EU Common Agricultural Policy (CAP) support measures (e.g. 'greening': beneficial practices for the climate), it is strategic that the most sustainable management of the agro-industrial by-products is compatible with overall climate change mitigation. Thus, we conducted an environmental analysis using a life-cycle assessment (LCA) technique in collaboration with the Basque Center for Climate Change (BC3, www.bc3research.com).

The boundaries for milk goat production system and alternative uses of the by-products are outlined in **Figure 4**. The farm data used were those generated from the trial described above, and therefore 2 experimental diets (tomato and olive by-products) were compared against the control diet. The study followed the methodology described in the international standards (ISO, 2006). The functional unit is 1 kg of fat and protein corrected milk (FPCM). Economic allocation was used to divide emissions between milk and meat produced in the farm. A 'cradle to gate' approach was considered, involving all the input and output related to goat milk production (figure 1). Data registered during diets experiment was used to describe feed inputs, milk yield, CH_4 emissions and manure production for the three scenarios compared. Additional data to describe farm activities, such as energy consumption, bedding material, productivity levels and replacement rates were modelled according to data collected from a typical dairy goat intensive farm in Andalusia. Data for describing crop cultivation stage for the production of the feed ingredients was also collected from available literature and databases (Ecoinvent v. 2.2), (EcoInvent Centre 2009). In accordance with European policies that promote the use of organic waste for land fertilization, and penalize dumping (Directive 1999/31/CE), composting was assumed as the baseline management option for the food industry by-products considered in the study (i.e. tomato wastes and olive oil by-products). Emissions and energy linked to compost production, the substitution of mineral fertilizers and potential C sequestration were accounted according to the results from the model. The CML baseline 2000 method was chosen for impact assessment. A total of four impact categories were selected among the so-called 'baseline impact categories': abiotic depletion, acidification potential, eutrophication potential and global warming potential (GWP). In addition, cumulative energy demand was also selected as an energy flow indicator of the energy use throughout the life cycle of the product. SimaPro 7.3.3 LCA software was used for the calculations.

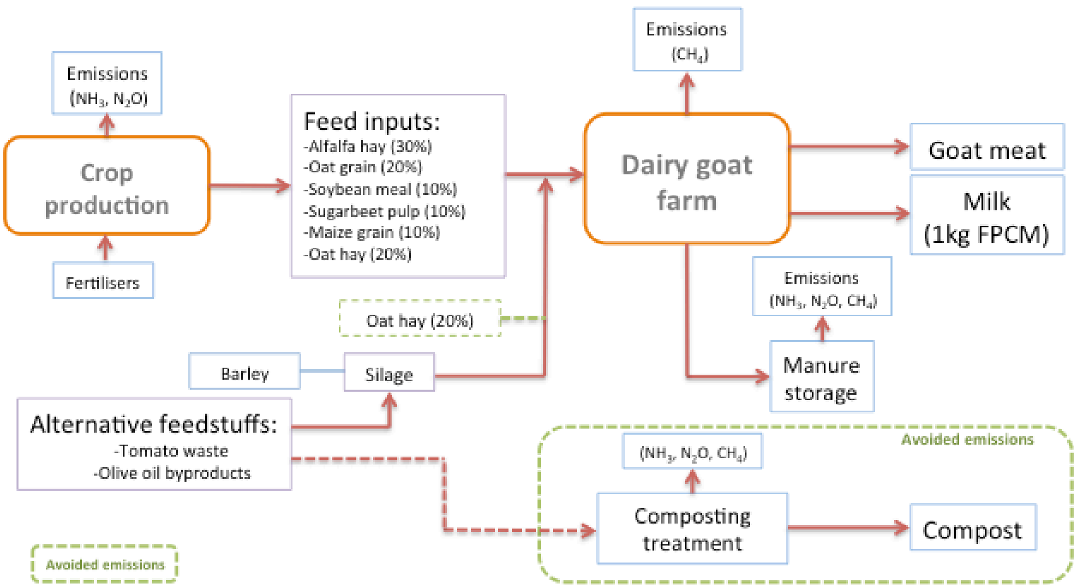

Figure 4. System boundaries for milk goat production system and alternative uses of the by-products.

The experimental data were integrated within a modelling framework comprising different sub-models to describe the farm system and associated production chain. A new model describing carbon and nitrogen losses from solid waste was applied to estimate the emissions associated with the baseline scenarios for food by-product management. The assessment revealed that the two dietary strategies achieve GHG reductions (~12–19% per kg milk). In both cases, nitrous oxide and carbon dioxide emissions from crop production were partially reduced through the displacement of typical concentrate ingredients (**Figure 5**). An additional mitigation effect was obtained when including tomato wastes in the diet because it reduced the methane emissions from enteric fermentation. Results suggested that use of agro-industrial residues for feeding is a feasible mitigation option in this case. However, as organic by-products could have alternative uses (bioenergy, soil amendment), with different implications for land use and soil carbon stocks, a more complete overview of both scenarios is recommended. Potential trade-offs from non-GHG categories may play an important role in a decision-making process.

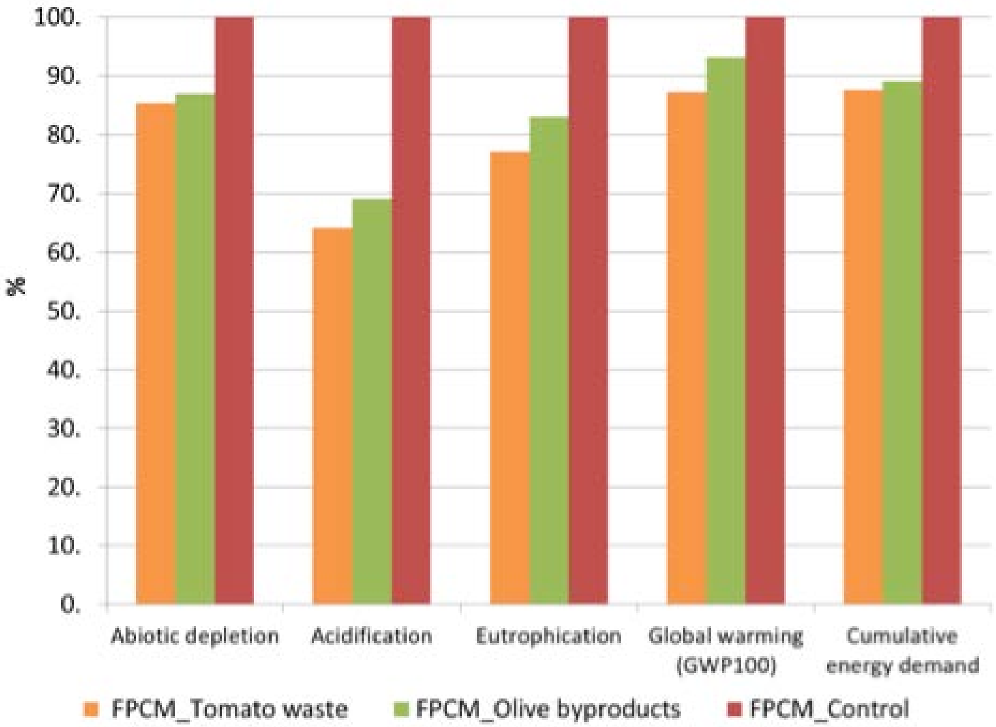

Figure 5. Main results of life-cycle assessment (LCA) for the three dairy goat diets analysed (TS, tomato waste silage; OS, olive oil by-product silage). Functional unit: 1 kg of goat fat- and protein-corrected milk (FPCM).

The results of the LCA were presented to farmers and retailers were impressed with the figures. CABRANDALUCIA is now developing a sustainability program to increase the competiveness of the dairy goat sector in Spain and the results of the LCA inspired further analyses relate d to the use of agro-industrial by-products.

2.2. Effect of pasture irrigation on grazing, milk yield/quality and overall animal health in dairy goats

2.2.1. Context

The primary aim of this on-farm trial was to assess the potential use of sown irrigated pasture under Greek conditions for grazing by dairy goats. The work focused on the use of natural resources in an environmentally sound manner. The target was to use semi-intensive husbandry systems for the production of desirable quality milk at high yield than is traditional. Because of the potential length of the herbage during a growth season in Greece we wanted to investigate whether it is possible to extend the grazing period of dairy goats to irrigated pastures into seasons when the supply of natural pastures is scarce. Production of such specialized irrigated pasture for goat's grazing has not been investigated in Greece before. Therefore, this study included a preliminary phase during which the feasibility of producing and maintaining a suitable sward for grazing by dairy goats was assessed while the effects of grazing on milk yield, milk quality and overall animal health and reproductive efficiency were tested in an on-farm trial. The study was conducted at Amalthia Farm, which is located in Ano Kaliniki Florina, Greece (http://www.agroamalthia.gr). The farm has been one of the key farms used in WP2 of the SOLID project. The herd consisted of 400 adult Damascus goats. The farm recently started to sell its own milk to the local market either as pasteurized or ultra-pasteurized. The farmer plans to extend this market in large cities and also to produce a variety of dairy products. However, the main challenge for the farmer has been the cost of feeding. Therefore the objective of this participatory study was to test the effect of grazing irrigated pastures as a feeding strategy that would help to reduce feeding costs. Moreover, the use of grazing would help the farm marketing a more environmental friendly method of milk production. At farm level, grazing would reduce the costs of purchasing forages and more importantly would contribute to better animal welfare, and prolong the productive life of the dairy goats.

2.2.2. Methodology

A draft protocol was established in late 2012 when the farm decided to use irrigated pasture for grazing. Soil data were initially obtained by analyzing soil samples before the establishment of irrigated pasture. A mix of seeds specifically recommended for pastured goat was sown in November 2012 and it was well established in April 2013. The goats were turned out grazing in group in May 2013 and data were collected for two years covering two full lactation periods (see Table 3)

Table 3. Methodology used and data collection

Parameter	Method	Frequency of data collection	Person responsible
Milk yield and assessment of of individual goats	Recorded in parlour by hand milking and weighting the milk	Monthly	DAPVET team
Herbage measurements	Adapted methodology	Monthly	MSc Student (Sophocles Pinopoulos)
Soil moisture measurements	Adapted methodology	Weekly	Farmer – Dimitris Minipoulos
Overall farm financial data	Farm records	Monthly	Farmer – Dimitris Minopoulos

Figure 6. Goat grazing in irrigated pasture

Figure 7. Goat grazing in irrigated pasture supervised by the farmer D. Minopoulos

Data collection: Following establishment of the pasture, the goats were adapted at grazing the irrigated pasture for about one week. The animals grazed as a single flock but with different levels of supplementary feeding indoors, in order to test the efficiency of the different feeding strategies (Group A: high level of supplementary feeding indoors and Group B: low level of supplementary feeding indoors). Quantities of the feedstuff provided were adjusted to meet the nutritional demands of each one of the two groups. Body condition score was estimated at monthly intervals (Figure 11). The available pasture consisted of two Paddocks (A and B) which covered a total area of 32 acres (20 and 12 respectively), located very close (about 20 meters distance from the goat shed) to the farm buildings. Mean sward surface height (SSH) was assessed at regular intervals from individual measurements at 39 random points in Paddock A and 35 random points in Paddock B (Figure 8), using a designated sward measuring stick. Chemical analyses of pasture grass and of concentrates and forages fed indoors were performed. These analyses included the estimation of crude protein, crude fiber, ether extract, inorganic matter, and dry matter content. Milk samples were collected at monthly intervals and they were subjected to further analyses in order to assess Somatic Cell Count (SCC, Fossomatic technology was used), Solids Non Fat (SNF), Colony – forming units (CFU), as well as fat, protein, and lactose content (Milkoscan technology was used). Test – day milk yields were also recorded monthly.

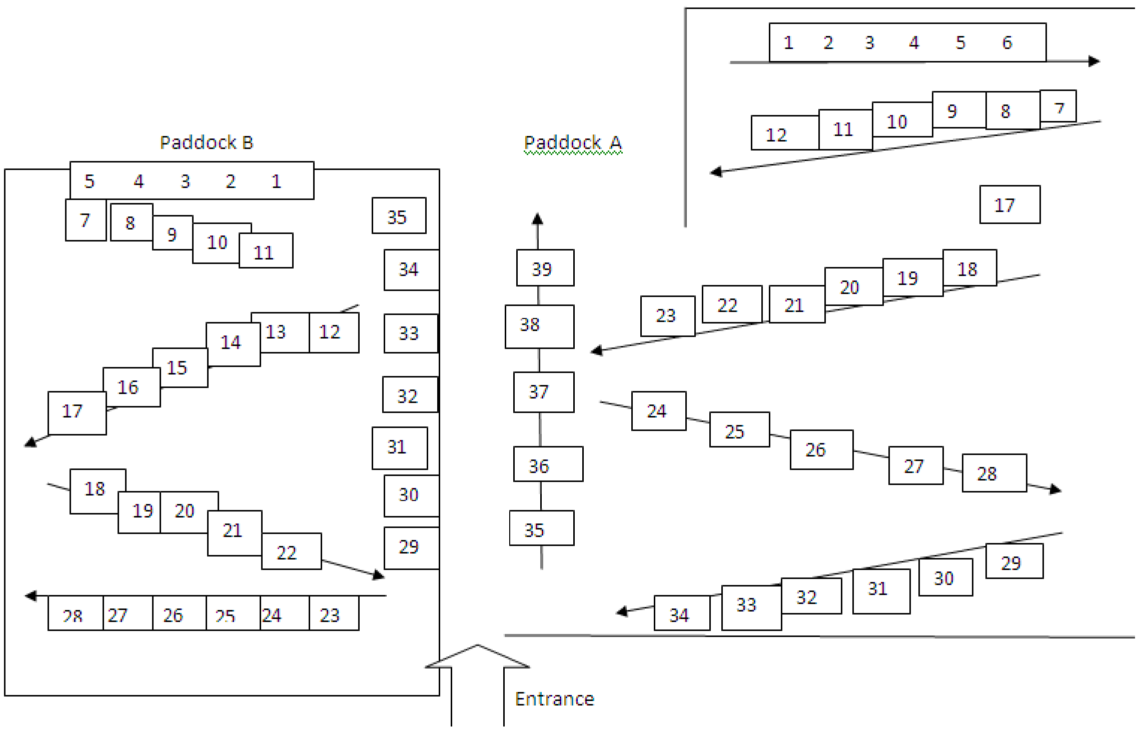

Figure 8. Schematic presentation of swards measurement points in the paddocks

Figure 9. Designated stick for sward height measurements

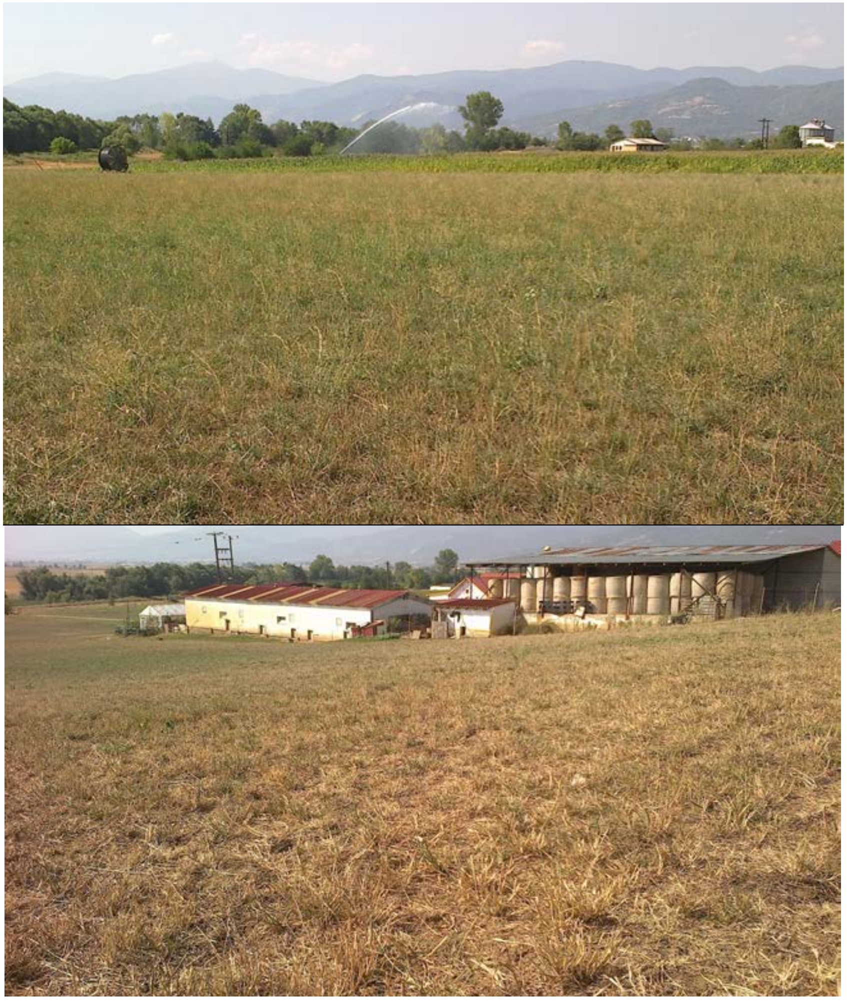

Figure 10. Irrigation and the condition of the pasture in late August 2013

Considering the problems with irrigation in late summer of 2013 and the variation in sward quality in the two paddocks it was decided to continue the measurements of sward surface height (SSH) at monthly intervals for another year in order to obtain detailed information of sward measurements. Also herbage mass and herbage growth rate (kg DM/ha/d) will be measured by the exclusion cage method (n=4). Soil moisture content (SMC) was estimated weekly by the farmer.

2.2.3. Results

Table 4 shows the average values regarding the physical and the chemical composition of the feedstuffs that were offered to the dairy goats. The data are based on different samples obtained in four different times.

Table 4. Physical and chemical composition of diets offered to dairy goats

Feedstuffs	Water (%)	Ash (%)	total fat (%)	crude protein (%)	crude fiber (%)
Ration fed indoors					
Commercial concentrate	9,8	8,5	2,5	21,3	7,1
Alfalfa hay	9,3	6,5	2,3	22,8	32,2
Barley Straw	6,6	8,5	0,9	7,8	36,7
Silage	65,3	4	4,8	3,6	18,3
Grazing					
Meadow hay	82,1	2,5	3,9	6,3	8,6

Considering the time that the pasture was available for grazing for the first time (May 2013) as well as the lactation period of the two groups of dairy goats used two measurement of individual milk yield were performed. The first measurement took place on 01-07-2013. Average milk yield of group A (high level of supplementary feeding indoors) was 2.23 kg per doe. In terms of milk quality the average values of fat, protein, lactose and SNF were 5.05%, 3.48%, 4.25% and 8.64% , respectively. In group B (low level of supplementary feeding indoors) the average milk yield was 1.78 kg per doe whereas the average values of fat, protein, lactose and SNF were 2.47%, 3.08%, 4.45% and 8.22% respectively. The second measurement took place on 04-08-2013. The average milk yield of group A was 1.97 kg per doe. Average prices of fat, protein, lactose and SNF were 4.16%, 3.61%, 4.17%, and 8.68% respectively. Average milk yield for group B was 1.57 kg per doe. Average prices of fat, protein, lactose and SNF were 3.1%, 3.33%, 4.21% and 8.22% respectively.

Following the first year of the work and considering all the results obtained from Task 2.3 of the SOLID project in the Amalthia farm (continuous monthly monitoring of 104 individual dairy goats) we have established a close collaboration with the farmer in monitoring farm records. So far the farmer is convinced that effective management will be the key of success in his business and he is keen to contribute further to task 1.4.

2.2.4. Conclusions/Recommendations

These preliminary results helped to estimate the potential of the use of irrigated sown pasture in semi-intensive dairy goat production systems in Greece considering the cost of feeding indoors. On the completion of the study the results will be important to make decisions about the feeding management of dairy goats considering the increasing costs of purchasing feedstuffs. The notion is that if such practice will be beneficial for the farm then it could be adopted by many other dairy goat farms that currently rely mainly in grazing communal areas that are located at significant distances from the farm. The latter is a significant cost in term of required personnel. On the other hand during the summer and early autumn months the availability of grazing in scarce.

2.3. Adaptation of local and imported dairy goats breeds in low input systems

2.3.1. Context

The Greek national flock of dairy goats is ranked as the largest national flock in the E.U., counting more than 3.5 million female dairy goats (about 45% of the goats in E.U.). The most prevalent production system is the low-input, semi-extensive, pastoral system, with goats grazing throughout the year in shrublands and woodlands on semi-mountainous and mountainous areas. Around 3.1 million goats (about 90%) belong to different local types (approximately 39 types). They are reared either within a semi-intensive system (about 82%) or within an extensive pastoral system (about 8%). The remaining population (10%) comprises of high producing goats of Skopelos breed, which is the only local breed that has been monitored through a genetic improvement program as well as foreign dairy breeds (Damascus, Alpine and Saanen) and their crosses. While many farmers, industry partners and stakeholders perceive the Eghoria breed to be better adapted to conditions of low-intensity milk production systems, the complete lack of scientific data on relevant phenotypic or genetic differences between different goat types makes it difficult to assess their suitability for typical Greek low-input dairy production systems.

Another important issue is the association between milk yield and the health status of the udder. Subclinical mastitis (SCM) is one of the most challenging diseases in dairy goat herds, since it has been linked to production loss, downgrading of milk quality, increased replacement cost and the associated veterinary expenses (Koop et al., 2010). Low-input management schemes, which are considered compatible with the principles of organic farming, have not been assessed in terms of goats' udder health status, their productivity, and the hygiene of produced milk. Information about the epidemiology of subclinical mastitis and its effect on milk yield in goats is limited. Also, data regarding the most significant pathogens associated with its incidence are rather scarce. The evidence in the literature suggest that the rate of isolation of different pathogens from goat herds is strongly related to the herds' overall hygiene status and their general management schemes (Mc Dougall et al., 2002; Bergonier et al. 2003; Contreras et al, 2007).

The aim of this study was to assess the phenotypic differences between goat breeds in Greece which are perceived to be adapted to "low input systems" in comparison to conventional genotypes in terms of productivity, animal health and welfare and milk quality. The specific objectives were:

i) to assess the performance, milk yield and milk quality characteristics of two local breeds and one foreign breed of dairy goats in Greece (Eghoria Goat, Skopelos, and Damascus),
ii) to record the major pathogens associated with subclinical mastitis and to calculate their incidence rate during the milking period and
iii) to estimate the effect of subclinical mastitis caused by specific pathogens on milk yield of goats.

2.3.2. Methodology

This was a participatory study as mentioned above in Table 3. The involvement of the farmer was a key component in carrying out the research which was coordinated by the DAPVET team, however decisions were unanimous regarding overall planning and results exploitation. Two different Greek dairy goat breeds (Eghoria goat and Skopelos) were compared with an imported breed (Damascus), that is used in conventional breeding programmes, within a dry, low input environment in Greece which is a typical Southern European low input goat milk production system. Based on the results from work in WP 1 of the SOLID project, approximately 900 milking goats (n=300 per breed) were initially selected in 7 herds (Herds 1 and 7: Skopelos, Herds 2 and 3: Eghoria, Herds 4, 5 and 6: Damascus). The 7 herds that were selected belonged to clusters 2 (all the Eghoria and Skopelos and two flocks of Damascus) and 3 (one flock of Damascus).

Animal Performance, milk sampling, milk yield and milk quality assessment

The study included monthly monitoring and milk sampling of individual goats that started immediately after weaning and continued for five months (which is the average milking period in semi-extensively reared goat herds in Greece) during the course of two successive milking periods. At the commencement of the work and on a monthly basis, each goat was initially subjected to body condition scoring. Details of the methodology used can be found in SOLID Deliverable 2.5.

2.3.3. Results

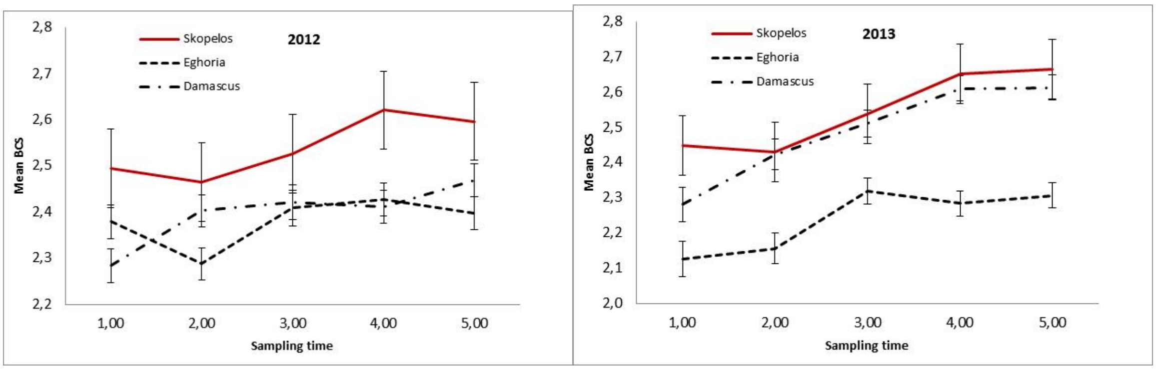

Figure 11. Evolution of Body Condition Score of goats of different breed, across herds, during the two years of the study (2012, 2013)

2.3.3.1 Health and welfare traits

Apart from BCS measurements another indirect assessment of goat performance was their health and welfare status that was the subject of the detailed clinical examination done concurrently with BCS of individual goats. It resulted in a large dataset containing data regarding injuries, skin lesions, abscesses, diarrhoeas, hernias, ocular defects, discharges, arthritis, overgrown claws, lameness, asymmetry between the two halves of the udder, udder abscesses and clinical mastitis. The results across the studied goat herds showed a high prevalence of overgrown claws (median 10.6%, IQR 8.7 to 44.2%), udder asymmetry (median 18%, IQR 7.9 to 23.2%) and skin lesions (median 5.3%, IQR 0.0 to 19.1%). One of the studied herds (herd 2) had the highest prevalence of ear (13.2%) and horn injury (4.0%), ocular discharge (4.0%), blindness (2.0%) and clinical mastitis (0.7%). The highest prevalence for nasal discharge, skin lesion and udder asymmetry were observed in herd 3 (16.6, 42.4 and 35.1%, respectively), whereas, herd 4 had the highest prevalence on arthritis (5.8%) and overgrown claws (44.2%), which resulted in the highest prevalence of lameness (3.8%). Body abscesses and overgrown claws were more prevalent in herd 5 (about 64% and 15%, respectively) and udder abscesses in herd 6 (about 6%). Among the indicators studied, udder asymmetry had the highest incidence rate, and cumulative incidence (about 123 new cases per 1000 goat-months and 43%, respectively) followed by overgrown claws and nasal discharge (about 70 and 56 new cases per 1000 goat-months and 27% and 20%, respectively). The lowest incidence rate and cumulative incidence were observed for hernias, pulpitis and ocular discharge (0.3, 2.7 and 3.0 new cases per 1000 goat-months and 0.1%, 1.0% and 1.1%, respectively).

2.3.3.2 Milk yield and milk quality

Table 2/2 shows the average milk yield of the three breeds at the different sampling times over the two years of the study. The analyses of the data revealed significant (P<0.01) differences between the three breeds in their milk output; Damascus goats had the highest yield and the Eghoria the lowest throughout the milking period for both years. These results suggest that the Damascus breed has been well adapted to Greek condition that are mainly low input systems based on grazing in communal pastures. The results support earlier studies (Kominakis et al. 2000; Moatsou et al. 2006) regarding milk characteristics and the genetic potential of Skopelos goats. The results in Table 5 also showed that all three breeds had a satisfactory persistence in milk yield. The Eghoria breed showed an abrupt decline in milk yield after the 3rd sampling, however the magnitude of decrease was similar to Skopelos and Damascus goats up to the last sampling. It should be noted here that some flocks raising Damascus and Skopelos goat have extended milking periods up to seven months. However, such flocks are exceptional considering that in practice the duration of the milking period in the national herd is usually 5 months.

Table 5. Milk yield (g/d/goat) between the three breeds of goat across all participating flocks according to sampling time during the two years of the study

	Year 1 (2012)									
	1st Sampling		2nd Sampling		3rd Sampling		4th Sampling		5th Sampling	
	Mean	s.e.	Mean	s.e.	Mean	s.e.	Mean	s.e.	Mean	s.e.
Skopelos	1784	41,5	1550	41.6	1148	40.9	1031	41.4	729	56.5
Eghoria	904	40.7	885	41.2	758	41.1	542	41.4	476	41.4
Damascus	2442	46.0	2076	46.7	1820	45.2	1593	45.7	1298	49.5

	Year 2 (2013)									
	1st Sampling		2nd Sampling		3rd Sampling		4 th Sampling		5 th Sampling	
	Mean	s.e.	Mean	s.e.	Mean	s.e.	Mean	s.e.	Mean	s.e.
Skopelos	1579	48.5	1660	43.6	1612	50.7	1243	53.1	872	54.6
Eghoria	923	61.7	772	48.9	858	43.8	491	48.0	438	46.6
Damascus	2124	56.7	1901	45.4	1666	47.1	1301	51.7	1067	55.7

Tables 6 presents data regarding quality characteristics of milk. It was one of the aims of the study to comparatively analyze the different quality characteristics and evaluate the microbiology of goat milk produced by the two local Greek Breeds (Skopelos and Eghoria) and one foreign breed (Damascus) that is believed to be well adapted to Greek climatic conditions. The results of the present study confirm most of the data reported in previous studies. Milk fat (%) and protein (%) were lower in Eghoria and higher in Damascus. A similar pattern was observed in SCC and TVC. The goats that belonged to Eghoria breed produce milk with the highest lactose and SNF levels.

Table 6. Quality characteristics of goat milk between breeds in all participating flocks during the two years of the study

	Year 1 (2012)			
	Skopelos	Eghoria	Damascus	s.e.d
Fat (%)	4.92	4.69	4.87	0.044
Protein (%)	3.76	3.72	3.95	0.023
Lactose (%)	4.49	4.52	4.29	0.014
Total solids (%)	9.14	9.14	9.13	0.023
Somatic Cell Counts ($\times10^6$/ml)	1.4	1.8	3.2	1.56
Total Viable Counts ($\times10^3$/ml)	53.1	84.2	218.4	13.9
	Year 2 (2013)			
	Skopelos	Eghoria	Damascus	s.e.d
Fat (%)	4.84	4.68	4.70	0.042
Protein (%)	3.79	3.58	4.03	0.023
Lactose (%)	4.22	4.29	3.99	0.015
Total solids (%)	8.90	8.74	8.91	0.021
Somatic Cell Counts ($\times10^6$/ml)	2.6	1.4	1.7	1.82
Total Viable Counts ($\times10^3$/ml)	171.3	124.0	291.0	20.29

2.3.3.3. Milk somatic cell counts and microbiological analyses

In dairy goats high values of SCC are considered as normal due to the different way of milk excretion especially at the last stage of lactation. However, high values of somatic cell counts (SCC) together with increased total viable counts (TVC) are indicative of poor health and hygiene of the udder in major species of milking ruminants. The mean values of Somatic Cell Counts ($\times10^6$/ml) and Total Viable Counts ($\times10^3$/ml) between breeds and between sampling times are presented in Table 6. In the studied farms the estimated incidence of SCM for the first and the second year of the study was 69.5 and 96.4 new cases of SCM per 1000 goat-months, respectively. Moreover, the estimated cumulative incidence of SCM was 24.1% and 31.7%, respectively for the two successive years.

During the study, a total of 755 out of 4576 milk samples (16.5%) were subjected to microbiological examination according to the predefined criteria. In 167 out of 755 samples (22.1%) the cultures were negative, whereas, in 33 samples (4.4%), more than two pathogens were isolated, possibly due to contamination. Therefore, these samples were excluded from further analyses. From the remaining 555 positive samples, 661 isolates were obtained: Four hundred and forty nine (80.9%) samples contained a single pathogen and 106 (19.1%) samples contained two different pathogens.. The majority of the isolates (90.0%) were Gram-positive bacteria whereas 2.7% of the isolates remained unspecified. *Listeria* spp. were not detected in any of the 154 milk samples analysed. The groups of pathogens isolated and the microbial procedures conducted from the assayed milk samples are described in more detailed in SOLID Deliverable 2.5.

2.3.4 Parasites

Approximately 2,000 parasitological examinations (from individual goats) have been performed including coprocultures for the identification of nematode genera. Table 7, presents the parasitic burden (mean, minimum-maximum and SD) for parasite species in relation to stage of lactation across breeds and year of sampling. The parasitic burden that was observed in the first sampling subsequently decreased. However, an exception was noted in the number of nematodes that showed a significant peak during the fourth sampling. Considering that the majority of goats used in the present study were raised under semi-extensive, low input traditional farms where the kidding period usually takes place in late January early February the spread of parasites is facilitated by climatic condition and animal movements (e.g., grazing).

Table 7. Parasitic burden (mean, minimum-maximum and SD) for parasite species in relation to stage of lactation of dairy goats in the two years of the study

		Nematodes	Cestodes	Pulmonary
		(n=417)	(n=417)	(n=417)
1st Sampling	Min	0.0	0.0	0.0
	Max	3300.0	450.0	1050.0
	Mean	139.3	2.4	12.8
	SD	350.15	24.15	69.23
		(n=412)	(n=412)	(n=412)
2nd Sampling	Min	0.0	0.0	0.0
	Max	1950.0	300.0	200.0
	Mean	107.9	3.9	1.7
	SD	240.80	26.51	13.85
		(n=411)	(n=411)	(n=411)
3rd Sampling	Min	0.0	0.0	0.0
	Max	3250.0	350.0	350.0
	Mean	139.2	3.5	3.4
	SD	390.70	23.55	23.70
		(n=396)	(n=396)	(n=396)
4th Sampling	Min	0.0	0.0	0.0
	Max	5150.0	350.0	150.0
	Mean	145.1	2.0	1.0
	SD	443.58	23.51	11.21
		(n=340)	(n=340)	(n=340)
5th Sampling	Min	0.0	0.0	0.0
	Max	2200.0	50.0	250.0
	Mean	57.4	0.1	4.6
	SD	213.63	2.71	23.70

2.3.5. Discussion

The goat study assessed phenotypic differences between indigenous and foreign goat breeds in Greece which are perceived to be adapted to low input systems in terms of productivity, animal health and welfare and milk quality. Task 2.3 provided a large database comprising 8,600 individual milk yield records and 8,300 records of milk quality (fat, protein, lactose, SNF, cells and TVC) as well as data of about 1,350 milk samples from individual goats that had been cultured for pathogens such as CNS, Staphylococcus aureus, Streptococci spp, Listeria and Coliforms. Considering the existing literature regarding Skopelos (Rogdakis et al. 1996; Kominakis et al. 2000; Moatsou et al. 2006). Eghoria (Zygoyiannis, 1987, 1994; Zygoyiannis, and Katsaounis, 1991) and Damascus goats (Constantinou, 1989; Mavrogenis and Papachristoforou, 2000) the results presented herein provide for the first time a comparative approach in milk components between these breeds.

Regarding animal welfare, the database included data for certain welfare indicators (condition of the ears and horns, ocular and nasal examination, palpation of leg joints, overgrown claws, locomotion score, vaginal discharge, body condition scoring, existence of diarrhea, palpation of the udder, udder asymmetry, udder abscess-fibrosis, udder skin lesions, myiasis, ticks, radiculitis, abscess, clinical mastitis and injuries). The welfare status of animal was also indirectly assessed by examining the parasitic burden of individual goats. Such data enhance the scientific knowledge regarding animal-based indicators for on-farm welfare assessment for dairy goats (Battini et al. 2014) and provide justified evidence of the impact of the examined production systems on goat welfare.

3. Main recommendations derived from studies conducted in dairy goats

1. Overall the experience in participatory research was rather positive for both scientists and farmers. The activities involved encouraging farmers to engage in experiments in their own fields so that they could learn, adopt new technologies and spread them to other farmers. With the scientist acting as facilitator, farmers and scientists closely worked together from initial design of the research project to data gathering, analysis, final conclusions, and follow-up actions. It is clear that new information, technologies and concepts may be better communicated to farmers through this approach.

2. The work presented in this document has shown that the use of by-products in dairy goats feeding is well justified by environmental, ethical and economic reasons, and should be promoted. However, the limitations (variability in supply and feeding values, logistics, hygiene, product quality, economics etc.) must also be considered. Research can help to developing best practises in the use of by-products. In the particular case of agro-industrial by-products in Southern Europe, they can provide a range of nutrient resources, which have potential to be used as replacement of a range of conventional feeds. As they vary widely in their nutritional value and therefore the practical use in diet formulation can be challenging. The high moisture content represents the main limitation for a successful use of some by-products by the feeding industry. This work has shown that ensiling tomato and olive oil derived by-products represent a valid strategy to maintain their nutritive value and ensure supply of these by-products throughout the year. Specifically silages made with tomato and olive by-products may replace medium quality forage (i.e. oat hay) in dairy goat feeding provided that the farm is within 50 km from the site of production of the by-product.
   Further to the nutritional attributes, the environmental benefits of using such by-products in dairy goats feeding have been shown by using LCA. The outcome suggest that the new dietary strategies tested offer promising overall GHG reductions, in relation to N_2O emissions (from feed production stages) and enteric CH_4 (in the case of tomato wastes) without productivity being compromised. These findings must be taken with caution as food industry by-products could have alternative and competing uses, other than feed, such as energy production and soil organic amendment. Assumptions made and categories evaluated should be considered carefully in a decision making process.

3. The potential use of irrigated sown pasture as an additional feeding strategy in semi-intensive dairy goat production systems was proven beneficial in term of animal productivity. Considering the cost of feeding indoors purchased feedstuffs and the particular climatic conditions in Mediterranean, establishing and maintaining irrigated pastures for dairy goat production systems is a viable practice particularly in areas where water is not a limited resource. Irrigated pasture could be beneficial for dairy goat systems particularly around the Mediterranean basin where harsh climatic condition occur during the summer that limit the grazing availability in communal areas. The study provided data regarding water use efficiency and pasture management in relation to dairy goat performance but also

in terms of environmental perspective considering the livestock carrying capacity of experimental paddocks.

4. Although low input systems are considered to be beneficial for animal welfare, under Mediterranean conditions dairy goats raised under semi-extensive, low input traditional farms or medium-sized, semi-intensive farms with low replacement rate and grazing availability, a variety of compromises to goat welfare may occur; those are mainly related to nutritional status, udder health, parasitic diseases and lameness.
   A remarkable incidence was observed of subclinical intra-mammary infection in low-input dairy goat herds, which resulted in a significant milk yield reduction for the infected goats. Among the isolated pathogens, CPS and gram-negative bacterial IMI were found to be associated with the most significant losses in milk production. Investigating the epidemiology of subclinical mastitis and its effects on production traits is critical for the establishment of effective preventive measures against subclinical mastitis and for the assessment of the sustainability of production in low-input dairy goat herds. Such data were communicated with farmers that participated in the study and have also being published popular magazines and in a refereed journal (Journal of Dairy Science 2016, DOI: 10.3168/jds.2015-10694) in order to reach a wider audience

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