Transportable prototypes for milking and dairy processing in wild or transhumant flocks

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Abstract

The aim of this research was the experimentation of a transportable integrated system for milking and dairy processing in wild or transhumant flocks. This system is made up of three elements: a module where a mechanical sheep and goat milking plant is installed; a module containing dairy machinery to transform the milk produced; and a lorry, type approved as an agricultural tractor, to transport, one at a time, the two modules following the transfers of the flock.

The prototypes were designed following the introduction of the EEC 92/46 and 92/47 directives, which regulate milk production and dairy products. In fact, also the shepherds who rear flocks in the wild and operate in protected areas or those who practise transhumance must have suitable premises and equipment to keep selling milk, cheese and ricotta in accordance with consumer protection regulations. The system meets the requirements of the law and can operate without direct connection with the water, gas or electricity mains supply, in the open field near the flocks and with only one operator to manage it.

The experimentation shows the functionality and suitability of the two prototypes for the production processes also in conditions where there are no infrastructures (water, roads, etc.) with optimal performances. The times taken to complete the milking operation and the dairy processing are comparable or shorter than those taken by the shepherds with the traditional methods. Moreover, the vehicle is able to transport a module off road in the predictable operative conditions.

Keywords: typical cheese, sheep farming, protected areas.

Introduction

With the introduction of the EEC 92/46 and 92/47 directives, which regulate the production of milk and dairy products, and were applied in Italy by means of the D.P.R. (Presidential Decree) no. 54 of 14th January 1997, also the shepherds who rear flocks in the wild and operate in protected areas and those who practise transhumance must have suitable premises and equipment to continue selling milk, cheese and ricotta in accordance with the consumer protection regulations. For this reason it is necessary to set up dairies with milking sheds that conform to the regulations. These solutions, however, are not consonant with the conditions under which shepherds who practise this form of sheep farming work. For these shepherds, in fact, the construction of buildings is not possible, because both of landscape constraints and their type of transhumant farming, which involves frequent movement of the flocks during the lactation period, so they must greatly modify the ways they produce and transform milk. Most shepherds, therefore, have found that they can no longer transform milk. Consequently, sheep farming has been abandoned as the shepherds, no longer being able to realise a profit from transforming the milk they produce, are obliged to sell it to the large dairy companies (Istat, 2005 and 2006), who deal with collecting it but fix disadvantageous prices. A great reduction in the number of sheep farms occurred between 1990 and 2000

(-40.5%); furthermore, the number of sheep fell sharply between 1999 and 2000 (-38.2%), a drop only partially made up for in 2001 (+22%). From 2001 to this date there has been a stability in the number of animals (Istat, 2005 and 2007).

The consequence is that some typical products are disappearing as, given they depend on pasturing, they cannot be guaranteed by the large companies. At the same time the protection and safeguard of the territory represented by the shepherds is coming to an end, particularly in fringe areas, which will soon be unpopulated.

In an attempt to limit this phenomenon, an integrated system to carry out sheep milking and dairy processing to produce *Pecorino* cheese and ricotta was designed.

Material and Methods

The system

In order to enable shepherds to produce and to transform milk in suitably hygienic conditions and in conformity with the current regulations, and to keep alive some traditions and foodstuff production an integrated system was designed and realised. It is made up of three elements: a module where a mechanical sheep and goat milking plant is installed; a module containing dairy machinery to transform the milk produced; and a lorry to transport, one at a time, the two modules following the transfers of the flock.

The system, intended for flocks of 200-400 animals, was designed in such a way as to be managed by a single shepherd, who should be able to carry out the milking, the transformation of the milk and, with the help of the vehicle (when free of the containers), the transport of anything necessary both for the functioning of the equipment (water, Diesel fuel, GPL, etc.) and for the needs of the flock and shepherd (fodder, feed, dairy products, food, etc.) as well as the periodic transfer of the containers.

The modules containing the milking and dairy processing equipment (fig. 1) are containers realised with sandwich panels, insulated with polyurethane and with smooth, washable, stainless sheet steel internal surfaces. These are anchored to a framework of rectangular steel pipes that have the function of both sustaining the equipment installed and making the structure rigid. At the corners of the framework there are four telescopic legs, commanded by means of hydraulic jacks connected in parallel, which have the double function of raising the container in order to permit a single operator to load and unload the transport vehicle and of making it possible to level the floor, even if the ground is not perfectly flat. The decision to carry and not tow the modules, on one hand makes progress and manoeuvres on tortuous and dug up tracks easier, on the other it set limits on their dimensions. In fact, in order to remain within the limits established by the highway code, the modules were kept down to a width of 2.2 m and a length of 3.1 m and it was, moreover, necessary to make the roof of the milking container telescopic – on installation at the milking site this can be raised 60 cm higher with respect to its transport position. Moreover, in order to avoid duplication of equipment, a milk refrigerator tank, a water tank and a heat generator were installed only in the dairy processing module. Finally, there is only one generator set, driven by a Diesel engine and capable of supplying 5.5 kW of electric current, designed to meet the needs (at different times) of the two modules.

The vehicle (fig. 2), constructed for the transport of the milking and dairy processing modules, is classifiable as a tipping lorry but type-approved as an agricultural tractor, and is, therefore, subject to the specific regulations governing its maximum speed. It has a 2,068 cm^3 and 35 kW Diesel engine, one reverse and five forward normal gears, a two-speed transfer case, as well as the possibility of using 4WD (2WD can be disconnected). It can, therefore, be driven over loose earth with a steep slope and is thus suitable for use in the hilly fringe areas

where there is most pasturing. The vehicle, when it is free of containers, has a dump body with hydraulic hoist and four side boards; it also has a tow hook to attach an operating machine that can be powered by p.t.o.

Figure 1. The container

Figure 2. The vehicle with a module

As regards the milking module (fig. 3), the dimensions of the container permit the installation of a small milking plant with an eight place auto-blocking system realised with galvanised steel section bars and complete with feeder and troughs in stainless steel. The sheep enter and exit by means of ramps with railings. The rear doors, which during transport close off the animals' entrance space, constitute the first part of the ramps and are connected to the final sections, which, when the plant is not in use and during transport, can be kept inside the container. In order to control the entrance and exit of the sheep or goats at the sides of the auto-blocking system there are two sliding gates while, in order to reduce obstructions in the plan, the gangway to the stands is retractable, so that, while the animals are going in or out of the container, the operator is obliged to stay outside as the retractable gangway occupies his workspace. Once the gangway has been closed he can enter the module by two doors along the side of the container and proceed with the milking. The gangway, the two sliding gates, the feed doser and the block device are controlled pneumatically by jacks set in motion by means of a 1.5 kW electro-compressor and operated from a panel installed on the door near the animals' entrance gate; on the same door there is the general electrical panel.

The milking plant is a low milk line with four milking units and an automatic washing installation. Stainless steel was used both for the 40 mm diameter milk pipes and the milk terminal 32 dm^3 container. The milk pump (0.66 kW), with both the rotor and casing also in stainless steel, was installed immediately below the milk terminal. The vacuum circuit, made up of 42 mm diameter galvanised steel tubes is kept in depression by means of a vacuum pump, which, powered by a 2.2 kW electric motor and provided with a 55 dm^3 tank, is capable of aspirating 750 l/min of air at 50 kPa. A servocontrol is installed in the circuit making it possible to keep the vacuum constant. The pulsation of the milking units is maintained by two pneumatic pulsers regulated at a frequency of 100 pulsations per minute with a 50% ratio. The milking area is also provided with two douches, connected to the water supply by means of flexible tubes. These can be used to wash the animals' teats before the attachment of the milking units.

The equipment was placed under the floor of the auto-blocking system, which for the convenience of the operator was raised 90 cm higher than the floor of the container. It was isolated from the milking area by creating compartments in galvanised metal sheets in order to create separate areas for milking - milk area (milk pump, milk terminal, hygienic separator,

plant washing tank) and for the vacuum pump. This guarantees maximum hygiene for the milk area and, at the same time, reduces the surfaces to be washed.

The milking module is integrated with the dairy processing module and the milk can be sent either to the refrigerator tank or the processing tank in the second module.

In the dairy processing module there is a processing tank for the dairy processing of 200 litres of milk per cycle. The entire production cycle of pecorino cheese and ricotta can be realised in this, including the thermal treatment of the milk. The heating of the milk or the whey it contains is brought about by circulating hot water, produced by a GPL heat generator, in the interspaces of the processing tank, while to cool down the milk from the pasteurisation temperature (75 °C) to that required for the cheese making process (38 °C), water from an 800 litres tank is circulated in the same interspaces. The tank is equipped with a refrigerating plate to guarantee the prototype's constant performance also with a smaller volume of water.

According to the traditional pecorino making process, the formation of the cheese moulds involves removing the curd manually from the processing tank and takes place on a dripping table, equipped with a container for the collection of the whey drained from the cheese (fig. 4). Subsequently the same table is used to fill the baskets of ricotta. The dairy processing equipment is completed by one sink accessible from inside the container and another from outside, fed by a 12 Vcc autoclave, a 100 litres refrigerator and a cupboard for tools and detergents. All the liquid waste is collected in plastic tanks placed under the container: there is the possibility of separating washing water from the whey, which can be used as food for the sheep and goats. This would satisfy the requirements of decree no. 152 of 11th May 1999 and of executive decree 7th April 2007 on the protection of the waters from pollution which, however, in certain cases, provides for an agronomical use of liquid waste.

Figure 3. The milking module

Figure 4. The dairy processing module

Besides the entrance door, the container is also provided with two big windows with mosquito nets, which let in sufficient natural light. This can, however, be integrated in case of need by an artificial light plant functioning at 12 Vcc by means of an electrical accumulator, kept charged by a battery charger. There is also an aspirator installed in the roof, also this functioning at 12 Vcc. The electrical apparatus, powered at 220 V (heat generator, circulation pump, refrigerator, battery charger, etc.), is controlled from a general electrical panel, which in its turn can be connected, by means of a connection outside the container, either to the electricity mains supply, if this is available, or to a generator set.

By positioning the two modules strategically (fig. 5), the area in front of the entrances to both the milking and the dairy processing modules can be protected with a blind and it turns into a service area separated from the flock.

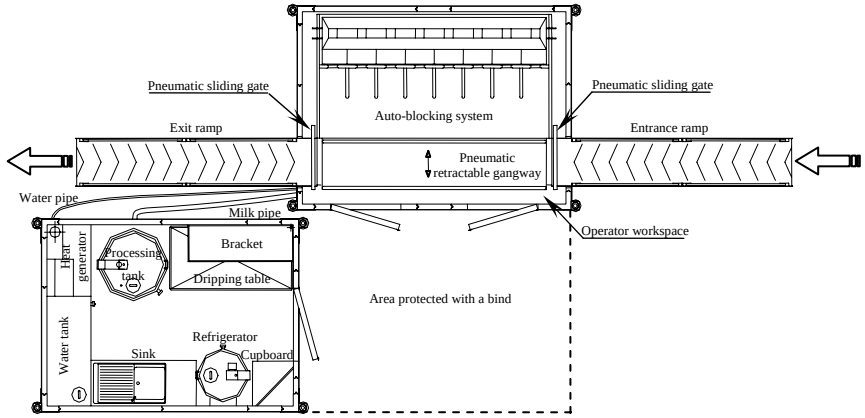

Figure 5. Plan of milking and dairy processing modules

The experimental trials

As the milking module was realised in a different research project from the one for the vehicle and the dairy processing module, during the experimentation it was not possible to carry out trials with the two modules connected. However, the suggestions of technicians and operators received in the course of numerous demonstration days were considered. Moreover, several trials were carried out to assess the functionality and the performance of the three elements.

As regards the vehicle, trials were carried out on this, both unloaded and loaded with the dairy processing module, which represents the most difficult load as regards both weight and height, in order to assess the traction control and identify the transversal stability limits in the conditions in which it would normally be used. In fact, transfers were carried out to determine fuel consumption on the road and to verify manoeuvrability and traction on tracks. Furthermore, loading and unloading operations were carried out with different soil conditions to assess whether only one operator would be able to complete the procedures.

Instead, the milking module was positioned for an autumn-winter-spring season in the pen of a flock consisting of about 100 sheep of the Comisana breed. Once the shepherds were familiar with the equipment, trials were carried out to measure the times taken to carry out the different elementary phases into which it is possible to break down the milking operation. In particular, the following times were considered: the time taken for groups of 8 sheep to enter the container and each take up a place in the auto-blocking system; the time taken for the operator to take a milking unit from its support and attach it to the teats (attachment time), to remove a unit from a sheep and attach it to another one (detachment/attachment time) and to remove the unit from a sheep and put it back on its support (detachment time); and the time taken by a group of milked sheep to leave the container and permit the start of a new milking cycle. Other times considered were: the massage time, which is the time taken for the shepherd, before detaching a milking unit, to manually facilitate the emptying of the udders; times in which the operator rested; dead times, essentially including the times necessary to verify the presence of dry sheep and the positioning of the milking units to facilitate the attachment operation. Another element considered for each 8 sheep milking cycle was the number of dry sheep.

Once the data had been collected, the average values for each of the times considered was calculated and the cycle time necessary for the milking of a group of 8 sheep was also calculated. This was done by summing the average times for entrance, exit and rest with the dead times and the average attachment, detachment/attachment and detachment times,

multiplied by four, this being the number of units installed, and 8 times the average massage time minus the percentage of dry sheep found in the year. Moreover, the data relative to the milking cycles where there were no dry sheep was extrapolated in order to determine the ideal cycle time and to find out whether the separation of lactating sheep from dry ones before milking might significantly reduce the time necessary to complete the milking of the entire flock. Finally, for each day on which the times were measured, the percentage number of fewer cycles that would have been necessary had the dry sheep been prevented from entering the milking module was calculated.

After all the flock had been milked, the quantity of milk produced was checked as well as the amount of water used to wash the plant and quantity of Diesel fuel required by the generator set that powered the equipment. As the dairy processing module was not available, the milk produced was collected in buckets or milk cans, the water supply was obtained by connecting the container to the water mains, while to produce the hot water necessary for washing the plant, an electric boiler powered directly from the mains was installed so as not to influence the consumption of the generator set.

As regards the dairy processing module, numerous processing trials were carried out with both 200 litres and 100 litres of milk per cycle to verify the flexibility of use. In some cases, moreover, two processes were carried out one after the other, even if this would not normally happen, in order to assess performance also when there is an overload of work. During the trials the time taken for each phase of the work was monitored as well as the changes in temperature of the milk during pasteurisation, of the whey used for the production of ricotta and of the water in the heater and inside the tank respectively during the phases of heating the milk or whey and of cooling the milk from the pasteurisation to the cheese making temperature. Other data collected regarded the consumption of GPL for the heat generator, the consumption of Diesel fuel for the generator set and the total water consumption for the process and the washing of the plant.

Results and Discussions

The trials carried out on the three elements of the system, showed that a single operator is able to manage the whole system. However, the results for each element are reported here.

Vehicle. It is manageable in manoeuvres also during the transport of a container and it is remarkably stable both on the road and on tracks (a limit of a transversal slope of 22% was identified). So it is able to carry out transfers along mountain tracks typical of the internal areas. On asphalted roads, on average 4 km were covered with a litre of Diesel fuel, while on bare tracks the traction control was excellent as regards both power available and the adherence of the wheels (the vehicle went up 30% slopes fully loaded). Certainly, as regards transport over long distances the maximum speed was penalised – on various occasions round trip distances of 500 km were covered, but these distances are very unusual in transhumance.

The loading and unloading of the modules onto and off the vehicle was found to be fully satisfactory: even on sloping ground not previously prepared, the shepherd-driver was able in just a few minutes to single-handedly load or unload the module from the loading platform without ever meeting any type of problem.

Milking module. In the flock with which the trials were carried out, on average 18% of the sheep were dry during the trial period. This led to the need for 17.5% milking cycles more than would have been necessary if the dry sheep had been prevented from entering the container. Figure 6 shows the times taken into account to complete the milking of 8 sheep both with and without dry sheep. The great difference in time is in the entrance time due to the presence of the dry sheep in the group, which slow down the entry phase. Without dry

sheep the attachment, detachment, rest and massage times are also shorter because the shepherd has less time to complete the operation. Only the dead time is greater.

The cycle time was 4.5 minutes/head when the dry sheep were also present and was reduced to 4.2 minutes/head when all the sheep were in lactation. These results indicate hourly capacities of 107.8 and 114.4 sheep/hour milked respectively with an increase in productivity in the latter case of 6.1%. This increase, considered with the 17.5% fewer cycles that would have been carried out if the dry sheep had been prevented from entering the milking module cannot be considered negligible. Finally, the time required to prepare the plant for the washing procedure after milking was on average 5 minutes. The washing time was 40 minutes but this does not require the presence of the operator as it is automatic.

The water consumption for the post milking wash was 230 litres, while the fuel required to power the Diesel-electric set was 1.3 kg. Although the water consumption may seem high, it cannot be reduced as it is this quantity of water that guarantees the elimination of traces of detergent from the milking tubes. Moreover, the 800 litre capacity of the water tank in the dairy processing module guarantees autonomy for an entire day. Besides, a frequent change of water ensures that the water will not become stagnant and therefore unsuitable for use in preparing food. Finally, the concentration of pollutants in the waste water is reduced and it should therefore be possible to discard it on agricultural land if there is no public drainage system available, as is likely, given the type of flock the plant has been designed for.

Dairy processing module. The plant was subjected to a wide range of tests with reference to the productive cycle used by shepherds for the production of *Pecorino Siciliano* cheese and ricotta. Overall the transformation of 200 litres of milk took, on average, about 3.3 hours, using 2.5 kg propane gas for the heat generator and 1.8 kg fuel for the Diesel-electric set. The incidence of each phase of dairy processing to produce cheese and ricotta is shown in figure 7.

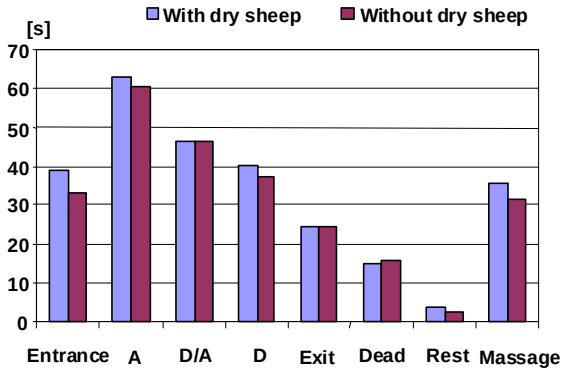

Figure 6. Times taken for each phase of milking operation

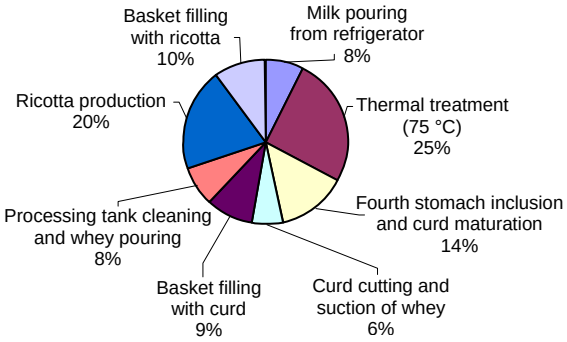

Figure 7. Incidence of each phase of dairy processing procedure

The longest time is taken by the thermal treatment (about 50 minutes: 25 minutes to heat the milk to the pasteurising temperature of 75 °C and 25 minutes to cool the milk from this temperature to the cheese making temperature of 38 °C using the 800 litre tank installed). So, the time to complete the dairy process, if shortened by the time necessary for pasteurisation, is comparable with the time currently taken by Sicilian shepherds to carry out the same process in the traditional manner. Clearly, both the consumption of gas and that of Diesel fuel can be markedly reduced if pasteurisation is not carried out, while the execution of thermal treatment of the milk at 65 °C did not appear to lead to a significant difference.

If the dairy processing is carried out only in the morning, it is necessary to keep the milk produced in the evening in the refrigerator and another 2,2 kg fuel is needed for the Diesel-electric set. Finally the water consumption to wash the plant was about 170 litres per cycle.

Conclusions

Since the introduction of community regulations 92/46 and 92/47/EEC, there has been a tendency to abandon the pastures and consequently inland and fringe areas. This has had serious repercussions both of a social nature, above all in areas where unemployment is high, and on the environment, given that the protection given by shepherds to the territory is no longer guaranteed. In order to limit this phenomenon, it was decided to intervene, realising suitable structures that would make it possible to continue following traditions and producing typical cheeses while also complying with current regulations. The study has demonstrated that this is possible: in fact, even if there are no infrastructures (water and electricity mains supply, buildings, roads and so on), the prototypes of the vehicle and the modules for milking and dairy processing realised can meet the requirements of shepherds with sheep or goats in the wild or transhumant flocks. Their operational simplicity has also been demonstrated, one person being sufficient for all phases of the work. The performance is optimal in that it is clearly superior to that obtained at present by shepherds.

The system proposed in this work could moreover also be used – if suitably powered and re-dimensioned – by shepherds with small non-migratory flocks. Instead of building or adapting existing buildings at great cost, they could use these ready made modules, connecting them directly to the water and electricity mains for water and power and to the drainage system for the disposal of liquid waste.

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