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ABSTRACT

L'utilizzo di materiale di scarto proveniente dalla lavorazione primaria delle nocciole (Perisperma) è stato il focus del seguente lavoro di tesi.

Il perisperma di nocciole o albume nocellare è stato ottenuto dalla tostatura delle nocciole Lucane, il quale è stato utilizzato sia nella dieta delle capre che nel processo di affinatura di formaggi (30 giorni) caprini con l'aggiunta di Marsala o di Grappa. Le nocciole utilizzate per la produzione di perisperma sono della varietà Tonda di Giffoni, che hanno la caratteristica di avere una buona pelabilità durante il processo di tostatura.

Il latte caprino aziendale è stato prodotto da capre autoctone lucane (Capra Frisa o Facciuta lucana) allevate, durante il periodo lattazione per circa 15 giorni, in Sistema agroforestry (pascolo all'interno del corileto aziendale) e con un'integrazione giornaliera di circa 800 grammi, di avena piselli, fioccati e di circa il 20% perisperma, sommnistrata parte in stalla circa 700 grammi e parte in sala di mungitura 100 grammi.

Il latte caprino è stato trasformato in caseificio, il nuovo prodotto caseario è stato stagionato per 60 giorni, per gli ultimi 30 giorni di stagionatura è stato affinato in perisperma di nocciole con aggiunta di Marsala e di Grappa.

I due gruppi di formaggi, dopo la stagionatura, sono stati valutati da valutatori addestrati mediante un consumer test.

In particolare, a 30 giorni di stagionatura, il formaggio affinato in miscela di perisperma di nocciole e grappa ha avuto un punteggio superiore a 7 ($P < 0.05$) per il giudizio complessivo (7.51 vs 7.09).

Parole chiave: Agroforestry, Latte Caprino, Perisperma di Nocciole, nuovo prodotto lattierio-caserario, consumer test

The use of waste material from the primary processing of hazelnuts (Perisperma) was the focus of the following thesis work.

The hazelnut perisperm or nocellar albumen was obtained by roasting Lucanian hazelnuts, which was used both in the diet of goats and during the aging process of goat cheeses (30 days) with the addition of Marsala and Grappa. The hazelnuts used for the production of perisperm are of the Tonda di Giffoni variety, which have the characteristic of being easy to peel during the roasting process.

The farm goat's milk was produced from native Lucan goats (Capra Frisa or Facciuta lucana) raised, during the lactation period for about 15 days, in an agroforestry system (pasture inside the farm hazelnut grove) and with a daily supplement of about 800 grams, of oats peas, flaked and about 20% perisperm. The integration was administered partly in the stable about 700 grams and partly in the milking parlor 100 grams.

The goat's milk was transformed into a dairy; the new dairy product was aged for 60 days, for the last 30 days of aging it was aged in hazelnut perisperm with the addition of Marsala and Grappa.

Trained evaluators using a consumer test evaluated the two groups of cheeses, after maturation.

In particular, after 30 days of maturation, the cheese aged in a mixture of hazelnut perisperm and grappa had a score higher than 7 ($P < 0.05$) for the overall judgment (7.51 vs 7.09).

Keywords: Agroforestry, Goat Milk, Hazelnut perisperm, new dairy product, consumer test

1. INTRODUCTION

Hazelnut (Corylus avellana L.) has very ancient origins: is supposed to be at the end of the last Glacial Age, about 10.000 years ago (Pessina A., 2002). Hailing from Mesopotamia, it then spread throughout Europe, especially in the Mediterranean and the Balkans. Fossils found in Germany, Switzerland and Denmark offer evidence that the fruits of this plant were essential part of a primitive men's daily diet which consisted primarily of berries and wild fruitis. The hazel was one of the very first fruit plants cultivated by humans.

The most intensive cultivations were located in 4 main areas, the most important is along the southern coast of the black Sea (Turkey), the second one in Italy, the third in Spain and the fourth is situated in North America.

In recent years, the demand of the product in a global scale has encouraged different attempts in many countries.

The production of hazelnut, called coryliculture, is actually going through a particularly prosperous period; according to experts, there is no more risk of overproduction in the world.

The hazelnut consumption has been growing a lot, everywhere, due to the confectionary industry and the recently demonstrated chemical-clinical discoveries on the beneficial effects of all nuts (Moscetti et al., 2015), for their antioxidant properties (Ghirardello et al., 2013) and in particular for their use in dairy production to create new products (Zeppa et al., 2013).

It is expected that the demand will double in the next ten years, therefore the requirement for 'quality' is also growing, with the consequent needs for traceable and sustainable supply chains.

Around the hazelnut, therefore, a culture has developed, the result of the work of generations of growers and hazelnut farmers, who have dedicated work and financial resources to this crop

Today, the framework is becoming more and more structured and coril growers are faced with an increasingly broad context. To provide an adequate response, therefore, the companies must increase their competitiveness by focusing not only on production quantity but also on quality. In addition to this, it is important for all actors in the coriliculture chain to have an overview of everything related to hazelnuts and coriliculture and to keep up-to-date on current research and results, new products, innovative and sustainable solutions.

1.1 AGROFORESTRY

Agroforestry combines agriculture and forestry to create productive and sustainable land-use practices. These practices exploit the interactive benefits of growing trees and shrubs together with crops and/or livestock in the same unit of land (AIAF - Associazione Italiana Agroforestale).

These systems represent the most common form of land use in countries of tropical and equatorial regions. since the 1950s-60s, In countries where intensive agriculture predominates, such as the EU, agricultural mechanisation and the trend towards monoculture has led to a dramatic reduction in agroforestry systems that used to be the normal.

Traditional systems, however, are still present in vast areas of Mediterranean countries, including Italy, especially in the more marginal areas that are less suited to intensive agriculture.

Agroforestry can be distinguished into different types:

- silvoarable: trees and shrubs intercropped with annual or perennial crops;
- silvopastoral: combination of trees and shrubs with forage and animal production;
- forest farming: forested areas used for production or harvest of natural-standing specialty crops for medicinal, ornamental or culinary uses; hedgerows,

- windbreaks and riparian buffer strips: lines of natural or planted perennial vegetation (tree/shrub) bordering croplands/pastures and water sources to protect livestock, crops, and/or soil and water quality;
- home gardens or kitchen gardens: combining trees/shrubs with vegetable production.

This thesis will focus on agroforestry and pastoral systems, which combines, in a unified management design, medium-long term forestry and/or agricultural production objectives with short term livestock production objectives (Ronchi B., 2008).

These systems are characterised by the implementation of a range of practices for using the natural resources of the territory (pastures), for different purposes and with deep ecological and economic interactions between the different components (McAdam, J. H., 2004).

The new management models are oriented more and more towards criteria of sustainability and multifunctionality, with integration and empowerment of the different environmental and production components, as highlighted in Agence 21 of the Rio Convention, where agro-forestry systems are mentioned as a model of sustainable land management.

Agroforestry systems are gaining interest in many countries, both European and non-European (especially in those most affected by land-use changes aimed at cultivating forest areas).

These are integrated systems that provide for the cultivation of tree crops (wood or fruit) and herbaceous crops (cereals or fodder) on the same agricultural area, with the possibility of also including animal husbandry (sheep and goats), in order to exploit fodder resources. The advantage of this management model is that up to three different types of income can be obtained on the same hectare of land:

- from the selling of wood or fruit;
- from the sale of grain;
- from the processing of fodder into meat, milk or other products

In addition to this, there are other aspects related to the possibility, through the adoption of this system, of mitigating the effect of animal husbandry on greenhouse gas emissions and increasing the adaptation of animals to climate change. With regard to mitigation, it is known that trees are able to sequester significant amounts of carbon in both aerial and root biomass, and an indirect role in protecting the soil from erosive phenomena has also been highlighted. With regard to adaptation, the microclimate created in agroforestry systems is considered useful for providing thermal comfort to animals during periods when the risk of extreme heatwaves is significant. Here, there is both a direct effect of shading on the animals and an indirect effect on improving the nutritional quality of fodder grown in agroforestry systems.

In Italy, especially in some regions such as Sardinia, there is a heritage of agroforestry systems that has always been a traditional form of farming and organisation of the agrarian landscape. There is definitely a need to conserve and valorise these forms of management, which represent a useful tool to combat the abandonment of marginal areas and to preserve the land and landscape. However, it is also necessary to develop new agroforestry models that are modern and efficient, designed for areas of intensive agriculture, to improve the sustainability of production systems and fight against phenomena such as erosion, loss of organic substance and greenhouse gas emissions, while guaranteeing a high standard of production.

In order to achieve this objective, however, investment in research is fundamental, in order to acquire all the knowledge necessary to build agroforestry system models that are best suited to Italian soil and climate conditions and that can truly guarantee sustainable intensification of production processes, in order to keep the competitiveness of Italian farms high.

It is in this scenario that the project 'CORILUS2 - PILOT PROJECT FOR THE DEVELOPMENT AND INNOVATION OF LUCAN CORILICOTURA' is set up, the objectives and results of which will be set out and analysed in the following chapters of this thesis work.

2. CORYLUS AVELLANA L.

2.1 BIOLOGY OF THE SPECIES

The hazel belongs to the order Fagales, family Betulaceae, subfamily Coryloideae, genus Corylus L (Allegrini A. et al., 2022). There are 18 species within the genus, but the most important one for commercial production is certainly Corylus avellana L.

The plants of C. avellana L. reach a height of between 3 and 7 m (Allegrini A. et al., 2022), have a broad crown, a shrub-like habit and are composed of a variable number of stems generated by the continuous emission of suckers that decay after 20-30 years. The stem is cylindrical, straight, the bark is glabrous, grey-brown with evident longitudinal furrows and scattered lighter lenticels. The root system tends to be shallow (50 cm) but can deepen to over 2 m for water catchment and extends beyond the projection of the crown. The leaves are petiolate, alternate, rounded-ovate with acuminate apex and serrated margin, deep green above and light green below with diffuse tomentosity. The gems are oval, small and sessile.

The plant is Monoecious, meaning both male and female flowers are present separately in the same plant. The male flowers, the catkins, appear at the end of the Fall on the branches from the previous year; they are pale yellow, 5-8 centimetres long and grouped in elongated “ears”.

Each flower has one bract and two bracts that protect four bifid stamens, each ending in two anthers. The catkins are already visible in the summer at the axil of the leaves and reach flowering in the period between January and February.

The female flowers are grouped in inflorescences called glomerules, enclosed in mixed buds. Each flower consists of a bicarpellary ovary primordium crowned by two short styles bearing prominent red stigmas. The mixed buds are found at the branch or at the axils of the catkins and on the peduncle of the catkins; anthesis is from January to March.

Comparing the time of flowering of the catkins with the time of flowering of the glomerules determines the dicogamy of the various cultivars. These are called

proterandine, when the male flowering precedes the female; proterogamous, when the female flowering precedes the male; homogamous, when the two flowerings are simultaneous. The hazel is a self-incompatible plant, i.e. pollination of female flowers cannot be carried out by pollen produced by the same plant or cultivar. This is a mechanism that allows the genetic variability of populations to be kept high and therefore has a greater capacity for survival.

Pollination is anemophilous, i.e. carried out by the wind. Fertilisation occurs after the pollination; the ovary, in fact, completes its development in three to four months before being ready for fertilisation, which occurs between late May and early June. Germination follows the flowering and occurs in March.

The hazelnut is an edible fruit, containing a high percentage of oil (Gellini R. et al., 1997), dry indehiscent to a single loggia, provided with a herbaceous involucre called a dome (helmet), which dries at maturity allowing the hazelnut to fall to the ground. Maturation occurs in a staggered manner between August and September and can take up to four weeks. The seed, wrapped in a film called perisperm with a protective function, is covered by the lignified shell. The fruits are normally clustered in groups of 2-4, varying according to the cultivar.

Fig.1 Catkin and glomerulus

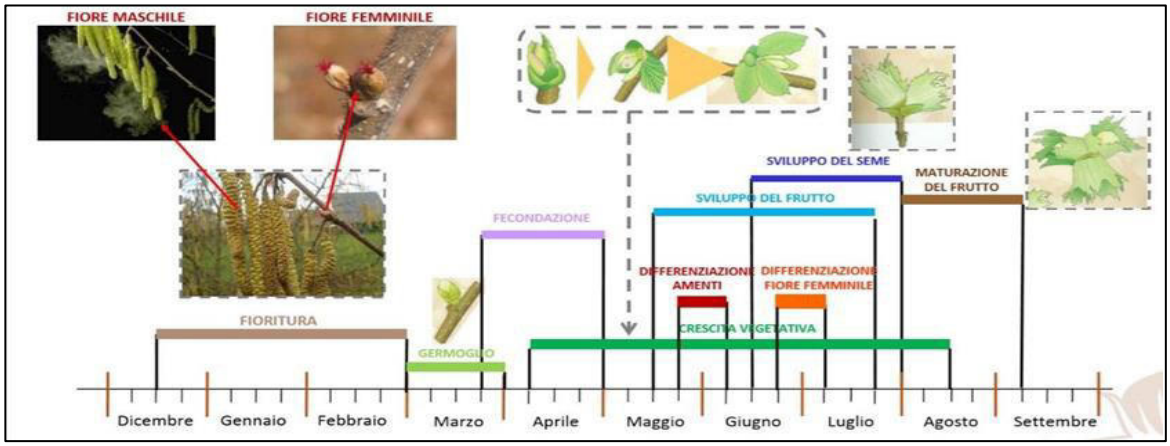

Fig. 2 Phenological phases of Corylus avellana L

2.2 ATTITUDE AND LIMITING FACTORS TO CULTIVATION

The distribution area of the hazelnut tree (C. avellana L.) extends from Europe to western Asia.

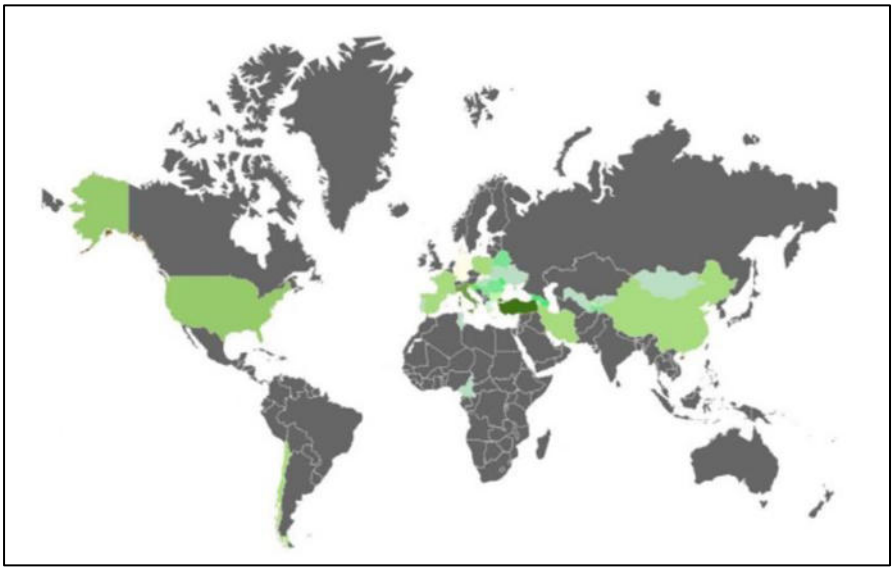

Fig. 3 Map of hazelnut cultivation (Allegrini A. et al., 2022)

The hazel is a common constituent of the undergrowth along the edges of coniferous or deciduous forests, from the phytoclimatic zone of the Castanetum to that of the Picetum. It grows naturally in areas ranging from 200 to 1700 m.s.l and can be considered a heliophilous species but tolerates shade, and is resistant to cold and wind (Pignatti S., 1979).

The variety cultivated finds its best environmental conditions in climates with mild, wet winters and cool summers. The climate is therefore the main limiting factor for the expansion of coriliculture and, above all, conditions its production and thus its profitability. The main variables to be considered in order to make cultivation economic are as follows:

- TEMPERATURE

C. avellana L. catkins tolerate temperatures of -15/-20 ºC, but become sensitive to temperatures below -7 ºC near pollen release. At bud break, which occurs in March, cold damage occurs at temperatures of -3.5/-4 ºC at the first leaf stage and 2/-2.5 ºC at the third leaf stage. Therefore, planting should be avoided in valley bottom soils where spring frost may occur. In general, the ideal temperature for plant growth is 23-27 ºC.

- RAIN DISTRIBUTION AND INTENSITY

The amount of annual rainfall required for economic hazelnut cultivation is 800-1000 mm, in particular, the water needs of the plant are between 80 and 100 mm monthly from April to August, below these amounts irrigation is recommended. In plants in production, water shortages between June and July (shell formation period) can compromise the normal dimensional growth of the hazelnut, and between July and August (seed formation and ripening period) can reduce seed development and shell yield. Instead, non-rainy periods during pollination and harvesting are desirable.

- AIR HUMIDITY

The leaf surface has a high transpiratory activity when the relative humidity of the air is less than 70%, under these conditions the vegetative development and water reserves of the soil are affected. In areas subject to moisture stagnation, fungal attacks may occur, causing the catkins and glomerules to dry out.

- WIND

During male anthesis, a light breeze is favourable to facilitate pollen transport to the female inflorescences. However, areas where there are strong, constant winds

should be avoided, as these make the plants' anchoring in the soil unstable and adversely affect their vegetative development. Hot summer winds and strong sunshine increase transpiration and reduce air humidity to the point of causing leaf blade desiccation.

- CHILLING REQUIREMENT

Plants in temperate climates exhibit the phenomenon of 'dormancy', a physiological state that is indispensable to prevent the plant from starting to vegetate before climatic conditions are favourable for development. Plants must accumulate a certain number of hours of cold and then a certain number of hours of heat to interrupt this period of vegetative rest. The way to determine these periods based on the sum of the hours at temperatures between 0 and 7 ºC for cold requirements, and the hours at temperatures above 4 ºC in the case of heat requirements. The vegetative organs of the hazelnut plant have different and typical needs for each variety. In most cases, catkins fulfil the needs in a short time and flower between December and February, followed by glomerules, which flower between January and February. Failure to meet requirements can lead to incomplete development of some organs of the plant.

- SOIL

hazelnut is adaptable to different types of soil exept clayey ones, due to the risk of root asphyxia, and very sandy ones because they are poor and too permeable. The ideal soil must be homogeneous and fertile. The hazel tree prefers deep, cool soils (1.5-2 m), especially in non-irrigated conditions, due to the ability to deepen roots to more than 2 m for water uptake. The optimal pH is between 6 and 7.8. pH values above 7.8 can lead to ferric chlorosis and poor mobilisation of trace elements, while values below 6 can lead to magnesium deficiency, reduce phosphorus availability and make organic matter decomposition difficult. In addition, concerning the content of active lime, it is estimated that it should not exceed 8%.

2.3 ITALIAN CULTIVAR

A description of the most prized cultivars according to their flavour characteristics and their aptitude for industrial processing is given below.

- TONDA DI GIFFONI

A native cultivar of Campania, it is cultivated in Italy particularly in the Salerno area, the Irno Valley and the Picentini Mountains, and to a lesser extent in Lazio. In 1997 it was recognised as a Protected Geographical Indication (PGI). The plant is of medium-high vigour with a semi-erect habit, high suckering capacity, rapid fruiting and high productivity (2-2.5 t/ha). In Mediterranean climates, flowering is proterandrous. Harvest time in southern Italy is quite early (end of August). The varieties Camponica and Mortarella can be used as pollinators. The fruits are of medium-large size (2.5-2.8 g), spheroidal in shape, with a light brown, medium-thick shell. The shelling yield is 46-48%. The seeds are spheroid-shaped and sparsely fibrous, have excellent peelability after roasting and have excellent organoleptic characteristics. The fruits are used for both direct consumption and industrial processing.

Fig. 4 Tonda di Giffoni

- TONDA GENTILE DELLE LANGHE

It is a cultivar native to the Langhe in the province of Cuneo, it is grown in all the suitable areas of Piedmont. It has been recognised as a Protected Geographical

Indication (PGI). Its cultivation is mainly localised in Piedmont as it is considered not very productive in different environments. The plant has medium vigour with a semi-erect habit and a medium-high suckering attitude. Flowering is of the proterandrous type. Harvest time is early (mid-August). The cultivars Camponica and Tonda Gentile Romana can be used as pollinators. The fruits are medium-sized (2.2-2.4 g), spheroidal in shape, with a medium-thick light-brown shell and medium presence of streaks. The shelling yield is 46-48%. The seeds are spheroidal to short cylindrical in shape, medium fibrous, and have a high peelability after roasting. The fruits are destined for the food industry and artisanal processing.

Fig. 5 Tonda Gentile delle langhe

- TONDA GENTILE ROMANA

A cultivar from Lazio, it is prevalent in the Monti Cimini area in the Viterbese region. In 2009 it was recognised as a Protected Designation of Origin (PDO). The plant is of medium-low vigour with a semi-erect habit and medium suckering attitude, with medium-high productivity (2-2.3 t/ha). Flowering is of the proterogynous-homogamous type. The cultivars Nocchione and Tonda di Giffoni can be used as pollinators. The fruits are medium-large (2.5-2.7 g), spheroidal in shape, with a light brown shell and medium-low shade. The shelling yield is 45-47%, the seeds are spheroidal in shape, not very fibrous. The fruits are intended for industrial use as they have good organoleptic qualities.

Fig. 6 Tonda Gentile Romana

- MORTARELLA

A variety original from Campania, rustic and resistant to cold, it is cultivated in almost all of Campania's cherry-growing areas with the exception of the Giffonese area. The plants are of medium-low vigour and semi-erect habit, have high suckering capacity and productivity (2.5-2.8 t/ha). Flowering is proterandra-omogama. Harvest time is early (mid-August). Fruits are of medium size (2-2.5 g) with short cylindrical shape and 46-48% yield at shelling. The seeds are short cylindrical in shape, sparsely fibrous and have good peelability. The fruits are intended for industrial use, due to their good organoleptic characteristics, or used for the production of semi-finished products.

- NOCCHIONE

Cultivar common in Lazio and used as pollinator of the Tonda Gentile Romana. The plant is of high vigour, with a semi-erect habit, high suckering capacity and high productivity. Flowering is of the proterandrous type. Excellent pollinator for the Tonda di Giffoni. The fruit is large (3-3.2 g), spheroidal in shape, with a thick shell, light brown in colour and not very streaked. The shelling yield is low (38-40%). The seed is spheroidal in shape, medium fibrous. The fruits are intended for industrial use and confectionery preparations.

Fig. 7 Nocchione

- CAMPONICA

A cultivar that is suitable for cultivation on clay soils and in higher elevation areas in Campania. The plants present high vigour and good productivity. Flowering is of the proterandrous type. The fruits are large (3.4-3.7 g), spheroidal in shape, with a shelling yield of 46-48%. The seeds are poorly fibrous and have good peelability after roasting. The fruits are intended for table use.

Fig. 8 Camponica

3. INTERNATIONAL AND ITALIAN CONTEST

The hazel was a very common species in European tree vegetation that developed after the Ice Age. It is native to our country and has been demonstrated through the analysis of pollen and plant remains in the peat bogs of Northern Europe.

The natural geographic distribution of C. avellana L. has been reported in Europe and parts of Asia, including in the south the Mediterranean countries until Syria and Lebanon, in the north Scandinavia and the British Isles, in the west Portugal and in the east the Black Sea countries, till Iran and the Urals.

The world hazelnut production area is about 660,000 hectares (FAO, 2018)

An average annual production of 835,000 t of nuts is mainly concentrated in two countries: Turkey (563,000 t) and Italy (112,000 t). Many countries all over the world have now become promising hazelnut investors, such as the USA (34,000 t), Azerbaijan (31,000 t), Georgia (32,000 t), but is produced also in Chile, Spain and France

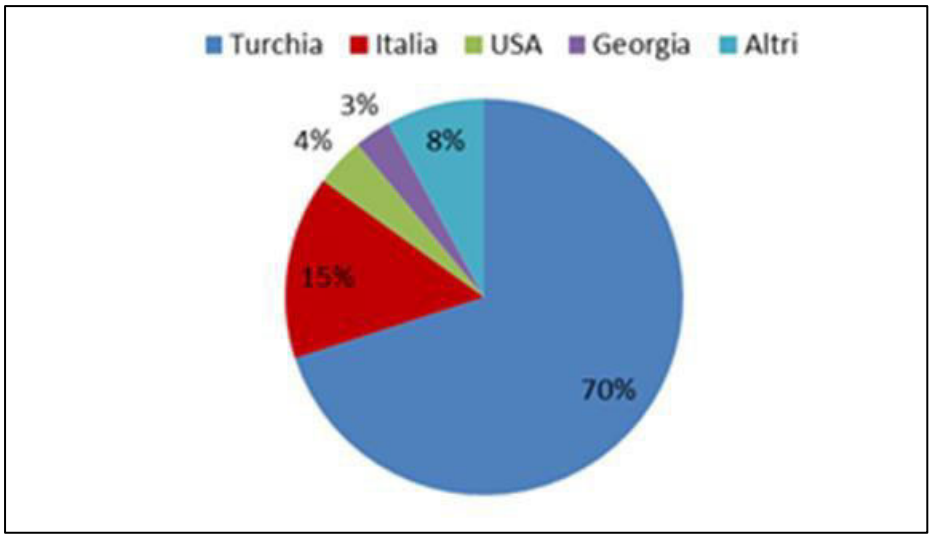

Fig.9 World production of hazelnuts

FAO data shows that this trend, in terms of soil occupation and nuts production, has been constantly growing in recent years, driven by the confectionery industry.

Turkey is the world's leading hazelnut producer, accounting for around 70 percent of the total world supply. Whereas, Italy, with a production of 15%, is the world's second largest hazelnut producer.

In Italy, the hazelnut tree is naturally widespread in all regions, where it grows in plains, hills and valley floors. In addition, it is found also in the Pavari phytoclimatic belt, the Fagetum (Cianfaglione et al., 2016).

It is traditionally cultivated in three regions: Campania, Lazio and Piedmont. In Sicily, hazelnut cultivation has significantly increased in recent years, but its production does not reach the quantity of the other mentioned regions.

Fig.10 Main Italian regions of hazelnut production

The Campania region is considered the site of the oldest hazelnut cultivation in Italy (Boccacci P. e Botta R., 2018). The area planted with hazelnut in Campania is 21,144 ha (ISTAT, 2017) distributed among the provinces of Avellino, Naples, Caserta, Salerno and to a lesser extent in the province of Benevento, with an average annual production of 38,000 t.

The hazelnut farms are 70% located in small hilly areas (max 2 ha) and with limited mechanisation. The remaining 30% are located in flat areas where clime and

farming systems are better. This provides better quality and competitiveness on the market. The varieties cultivated are: Mortarella (38%) and San Giovanni (37%), for industrial use; Tonda di Giffoni (12%), Tonda Bianca, Tonda Rossa, Camponica and Riccia di Talanico, for fresh consumption.

In Lazio region, the surface area planted with hazelnuts is approximately 22,962 ha (ISTAT, 2017), 90% of it located in the Cimino-Sabatino area in the province of Viterbo, with an average annual production of 35,000 t. The holdings are medium-sized (10-15 ha), located in flat areas with fertile and cool soils, often irrigated.

The most cultivated varieties are Tonda Gentile Romana (85%), Nocchione (10%) and Tonda di Giffoni (5%).

In Piedmont region, the surface area planted with hazelnuts is 22,594 ha (Anagrafe Agricola Regione Piemonte, 2017) about 17,600 ha are in production. The cultivation is distributed among the provinces of Cuneo, Asti and Alessandria, with an annual average production of 32,000 t. The traditional areas are characterised by non-irrigated farms, small size (max 2 ha), wide planting distances and bush training systems with many poles.

In the new plantings, the bush is planted with self-rooted single stem trees (monocaule) or self-rooted multi-stem bushes (policaule), more dense planting distances (around 300-400 plants/ha) and mechanised harvest. The most widely cultivated variety is the Tonda Gentile delle Langhe, in great demand for its organoleptic characteristics both by the confectionery industry and for table consumption.

In Sicily region, the surface area cultivated with hazelnuts is about 13,800 ha (ISTAT, 2017), mainly in the Province of Messina, but the Provinces of Catania, Enna and Palermo are also involved, producing an average of 13,000 t per year. The growers are still managed in a traditional way, as are the plants, leaving Sicilian coril production looking senescent and not very competitive. The main varieties grown are Sicilian, Ghirara, Minnulara and Lancinante.

3.1 THE CORILICULTURE IN BASILICATA REGION

Basilicata Region has extensive land suitable for hazelnut production in terms of soil and climate. The suitable territory represents an important opportunity for agricultural entrepreneurs in order to diversify and/or integrate farm income.

The reconversion and business innovation needs have been highlighted also by the Basilicata Region's Agriculture Department that has decided to sign a 'Framework Programme Agreement for the Development of Hazelnut production in Basilicata'.

The opportunity to introduce new intensive, sustainable and low-impact hazelnut cultivation, management and harvesting techniques is in fact a great occasion for the rural sector, where traditional crops (cereal and fruit) are in severe crisis due to the abandonment of territories. The market is growing rapidly in terms of quantity, quality and traceability. This quality must be targeted by improving processes and implementing new management techniques.

3.2 CORILUS 2 PROJECT

It is important highlight that the strong fluctuation in national and world supply leads to an exceptional fluctuation in prices at origin, raising the average price over the last three years to more than EUR 350 per quintal (in-shell product).

This has stimulated several Lucanian agricultural growers to invest in hazelnut cultivations and set up a 'business network' (Rete di Impresa Basilicata in Guscio). In this context, many of the Lucanian hazelnut farms were winners of a pilot project, CORILUS 2.

The 'CORILUS2 - PILOT PROJECT FOR THE DEVELOPMENT AND INNOVATION OF LUCAN CORILICOTURA' project was supported by sub-measure 16.2 of the Basilicata PSR. The aim is to support the implementation of pilot projects concerning the application and/or implementation of research results carried out in different scenarios, in order to introduce them into the geographical context of Lucania.

In the corylus project, a new productive process will be created aimed at obtaining a new dairy product by transforming the goat farm milk and inserting the waste of

hazelnuts (Perisperm or Hazelnut Skin), produced in the Basilicata region, into the manufacturing process.

In the framework of this project, a new dairy product was realised by introducing the waste from hazelnut processing, Perisperm or Hazelnut Skin. The "Azienda Agricola Lattiero Casearia di Mario Pietro Viola" produced the new product, where I carried out a research period of 6 months in the countryside of Guardia Perticara, from 03/06/2022 to 03/11/2022.

This part of researcher was carried out in collaboration with Prof. Luís Alcino da Conceição, Department of Agronomy and Vet Sciences Agronomic Faculty of the Polytechnic Institute of Portalegre, Portugal.

Fig.11 Viola's CHEESE FACTORY

3.3 CHARACTERISTICS OF VIOLA'S FARM

The "Masseria Viola" farm owned by Pietro Mario Viola is renowned for the high quality of its products. The farm covers about 120 hectares and is located approximately at a distance of 3 km from the town of Gorgoglione.

"Masseria Viola" is a family-owned business, where Pietro Mario and his wife Antonietta work together with their three workers

The 'Masseria Viola' has a history linked to family traditions, fuelled by a great passion for the agro-livestock sector, carried out on land in the Gorgoglione and Guardia Perticara area.

Over the years, investments have been made in the processing of the milk into cheeses that are commercialised in the main gastronomy shops and restaurants at local, National and international level.

Moreover, agricultural work has a strong polyvalent aspect, because farmers must combine several professional skills, ranging from agriculture to the mechanisation sector

The Viola farm has joined the Associazione Italiana Razze Autoctone a Rischio di Estinzione (R.A.R.E.) to safeguard the biodiversity, in order to contribute for the recovery of races at risk of extinction. In fact, either the 'Frisa Lucana' or 'facciuta' goat either the 'Nero Lucano' pig are breeded. Nowadays, about 50 goats and 200 pigs are growing for the best national ham and salami factories. Therefore, the strengths of Azienda Viola, are mainly related to livestock breeding with meat and cheese production. The livestock farming is conducted in a sustainable manner, respecting animal welfare and the environment.

Fig.11 Viola Farm's Goats and Sheep

The farm implements a semi-extensive farming system for sheep and goats; It is a very common practise in mountain areas. The animals are stalling in the coldest months (November to March) to protect them from the harsh temperatures. In the summer season, the animals are led to pasture, in vast pastures rich in grass where they can move freely. The feed of sheep and goats consists of grasses for the months when they remain in the pasture, and in the winter period, 60% for the barn of fodder, and 40% cereals and legumes. The total number of goats and sheep is about 200.

The new product cheese was made up in a dairy equipped by modern technological solution for milk processes, and, it produces high quality cheese in compliance with strict hygiene and safety standards.

The dairy laboratory is planned in a linear concept, so that the entire production cycle (milk transformation, maturation, care and marketing of the cheeses) is both hygienic and controllable. The maximum transformation capacity of the dairy is 1500 litres of milk per day, milk derived from the milking of the sheep and goats that are reared on the farm. The raw material (milk) is closely linked to the

seasonality of milk production. It has a maximun peak in the spring after the slaughtering of lambs and kids, while in the winter period it is a minimun

The cheese factory is well equipped: refrigerators, 2 vacuum machines, milking machine for sheep and goats, burner softener, Stewing caisson, 3 vats, 8 steel tables, 3 steel trolleys, 3 self-priming pumps, 3 whey tanks, 5 cold rooms, shelving, 7500 kg balance, 12 kg labelling machine, Steam.

4. HAZELNUT MANAGEMENT FROM IMPLANTATION TO QUALIFICATION

The planting of the hazelnut grove must be carried out very carefully since the decisions made at this stage condition the agronomic success of the crop. A preliminary procedure is required to identify either the critical points either the potential of the area under agronomic study.

It is possible to verify the aptitude of an area by consulting the Hazelnut Cultivation Aptitude Map in Basilicata before starting the typical field operations. After having identified the area to which it belongs (aptitude classes), it is necessary to carry out a field inspection. However, the next and indispensable step is the chemical-physical analysis of the soil in order to identify the potential and critical points.

The analysis involves a layer of soil between 5 and 60 cm, including all parameters, such as grain size, pH value, active lime, salinity, conductivity, organic matter, macro and microelements.

In addition, it can be possible carried out an x-ray of the soil that will provide information on the possible corrective measures to be applied in the soil, on all pre-planting work, on the cultivar to be planted and on the irrigation supply needed for each type of soil.

4.1 ASSESSMENT OF THE APTITUDE OF THE AREA

The hazelnut cultivation is a long-term investment (average duration of a plant: >=30 years) and for this reason it requires a careful assessment of its pedo-climatic adaptability to the different environments before it is implemented. Knowledge of the soil characteristics influences the success or otherwise of the plant. The aptitude cartography created on a scale of 1:250,000 provides general guidelines, for planning purposes, with the indication of possible limitations that allow even local choices to be directed in specific areas. A regional aptitude map for hazelnut cultivation is available for the Basilicata region and can be consulted on the Regional Geoportal, in the Agriculture Department section of the Basilicata Region website[1].

It is obvious that at the farm level, reference to cartography alone is insufficient, either in relation to microclimatic characteristics either in relation to soil variability. Consequently, the farmer wishing to undertake coril planting must refer to the 1:250,000 scale attitudinal cartography, even if it provides general indications, it highlights possible limits and allows the planning of future project actions at farm level. The planning of detailed pedo-environmental surveys on the area chosen for planting is fundamental and must be carried out prior to any project intervention, as the results of such detailed surveys influence both varietal and project choices. The image below shows the map of the suitability for hazelnut cultivation in the Basilicata Region.

[1] http://rsdi.regione.basilicata.it/viewGis/?project=D6ADDE7A-565C-5747-2577-136186FE73E5

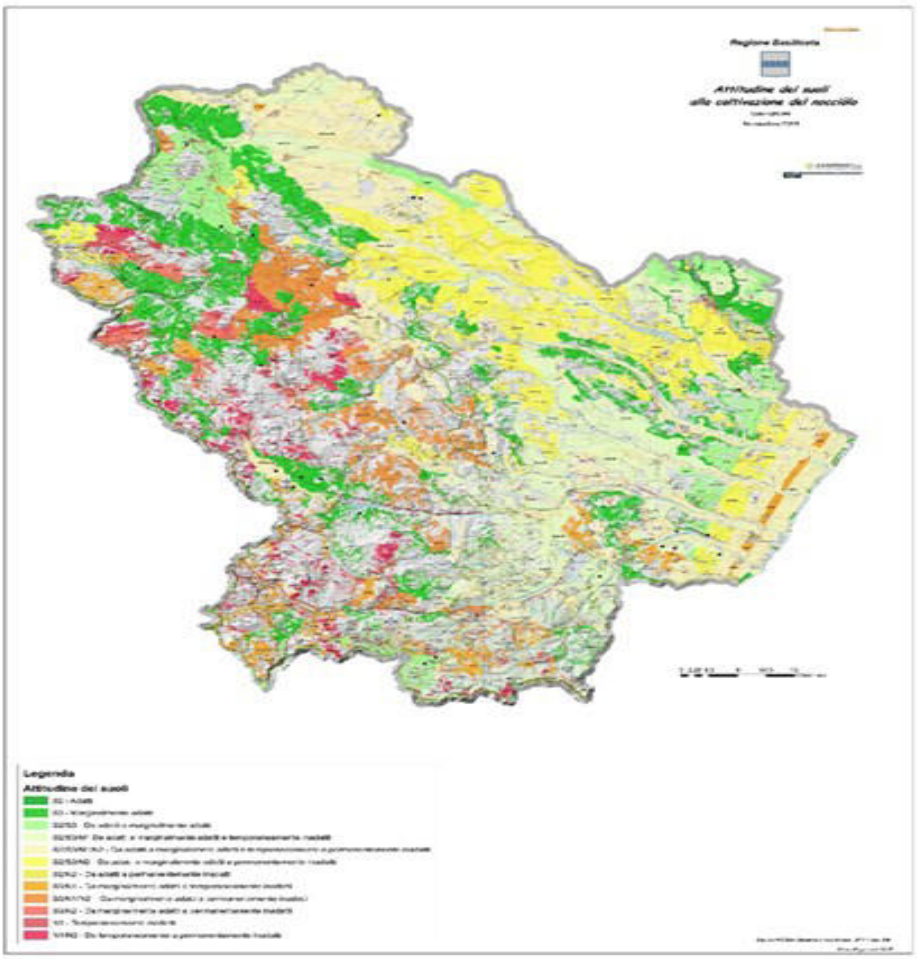

Fig. 11 Map of aptitude for hazelnut cultivation in Basilicata

4.1 PEDOCLIMATIC ANALYSES

The climatic factors that most interfere with hazelnut growth and production are late frosts and cold spells. Checking the frequency of late spring frosts in the period of ovary fertilisation (late March - late April) would allow an area to be chosen in order to have little frost damage that would compromise both juvenile growth and adult production. The establishment of a minimum number of cold hours is necessary for hazelnut flowering. Cold hours calculated according to the Utah system are between 700 and 900 hours at T°< 7 °C. The following table shows the cold requirement values of some cultivars grown in Italy and in Basilicata.

CHILLING REQUIREMENT			
Cultivar	**Male Inflorescence**	**Famale Inflorescence**	**Vegetative gems**
T.G. Trilobata	< 100	760-860	760-860
T.G. Romana	100-170	760-860	760-860
T. Di Giffoni	170-240	600-680	600-680
Camponica	170-240	290-365	680-760

Tab. 1 Chilling Requirement

In addition, it is relevant to check that the following parameters are well distributed through the year: the minimum (-11° C) and maximum (> a constant 34° C) temperatures, the frequency and duration of gale-force winds with speeds above 40 km/h (especially in the winter months during flowering-pollination) and the average annual rainfall of 800 -1000 mm.

A comprehensive analysis of the chemical-physical parameters of the soil is essential. The hazelnut tree prefers fertile, airy, medium-textured soils with a pH of 5.5 to 7.8, that are physically structured to allow regular water permeabilization in order to reduce water stagnation, deleterious to the hazel tree. Other important parameters are the active limestone, less than 8%, and soil conductivity < 2.3 mS/cm. In order to have a reliable soil analysis, it is necessary to take a sampling that allows the soil to be examined. Usually, soil samples are taken at two different depths 5-30 cm and 30-60, i.e. the depths that the roots explore during development.

4.3 IRRIGATION

The management of the water balance of the hazelnut grove particularly influences the development and productivity of the plant for all its life. In fact, irrigation helps the fruit to grow and prevents the plant from going into water stress, leading to premature fruit and leaf drop.

The period that is necessary to avoid water stress is between the formation of the fruit (clusters) and the formation of the perisperm (April - early August); after that,

water supply must be stopped to allow the fruit to complete its maturation by losing moisture and detaching itself from the hull.

On average, an adult hazelnut tree needs a water supply of 800-1000 mm; below this threshold, irrigation is recommended.

The most popular solution is micro-irrigation using a drip line. The most convenient solution for installing the drip line, on clayey and sloping soils, is to install it on a galvanised and/or polyethylene wire supported by wooden and/or metal posts at a one-metre high in the first few years. The irrigation system must be raised when the plant becomes an adult, in order to facilitate mechanical weed control during the first few years of planting and harvesting in the adult phase.

Another variant could be sub-irrigation by implanting a double line in the juvenile stages along both sides of the row and then burying a single line in the centre of the row in the adult phase of the hazelnut grove. This option is the most laborious.

4.4 PLANTUMATION SITE AND CULTIVATION FORMS

All elements concerning the planning of the hazel grove must be defined and oriented based the mechanical operations that are required.

In the past, it was common to apply a low planting density, trees where positioned at 5x6 or 6x6 metres of distance because it was considered opportune to leave space and light for the plant to increase in volume.

Today, in order to anticipate the earliest entry into full production, denser planting patterns are preferred. The most widely adopted planting layout today is the 5x3 (5 m inter-row, 3 m between plants), also known as the dynamic layout.

The forms of cultivation used for hazelnut trees are divided into two types:

- Policaule (Bushy pot and bush);
- Monocaule (Tree)

- Bush

The polycule cultivation is traditionally used for the hazelnut tree due to its vegetative habitus, and it is still apply in the Avellino area, for example. Topping

the stem at ground level, raise 6-7 shoots according to vigour and position that will serve to give life to the new bush. it is difficult to manage suckers and mechanical operations such as harvesting, but requires less maintenance than other forms of cultivation.

Fig. 12 Bush

- Bushy pot

It is a polycule cultivation made up by cutting the main stem at 30-40 cm once planted, and in subsequent years 4-5 vigorous branches should be selected and properly oriented to form a pot. In comparison to the bush, it allows the use of smaller planting distances and the simplification of sucker removal. The crown is smaller, making it easier to manage and more suitable for mechanical operations. The bush pot is the breeding system that makes the vegetative development needs of the plants to coexist with the technical operational needs of agriculture.

Fig. 13 Bush pot

- Tree

Monocolaule, tree cultivation is typical for orchards. This system has a trunk scaffold 70-8 cm above the ground. It has the same advantages as the bush pot but must be used carefully in hot and windy areas due to the risk of burning the trunk and uprooting. Particularly suitable in flat areas, where most of the cultivation operations are carried out mechanically, it does, however, require more time and labour for pruning operations than the other systems.

Fig. 14 Tree

Another important aspect to consider during the design of the hazelnut grove is the position of the pollinators inside the planting pattern. The hazelnut tree, as already mentioned, is self-incompatible for pollination, so pollinators are needed, which should be at least 20% of the total number of plants in the hazelnut grove. Their arrangement depends on the direction of the prevailing winds to allow good, uniform pollination, as can be seen in the image below. They are usually set up, for small plantings of a few hectares, in side rows covering the entire planting area, while for larger fields they are set up in blocks.

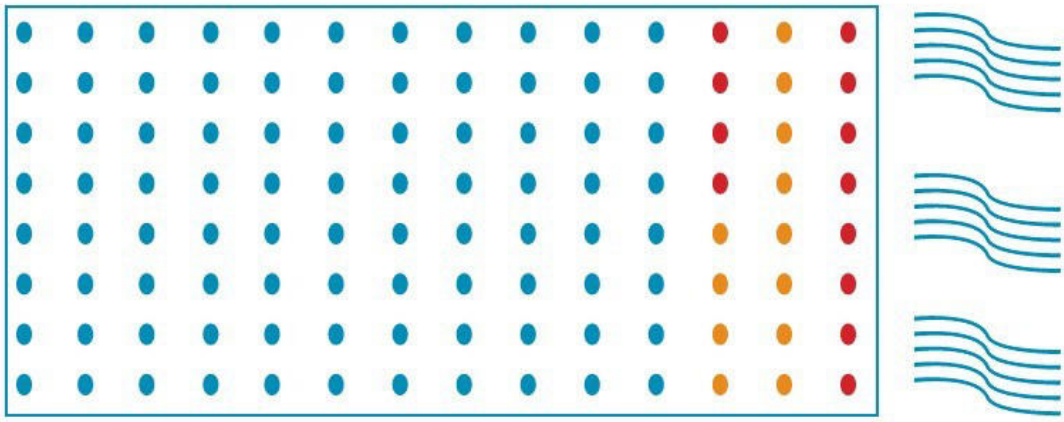

Fig. 15 Disposition of plants for optimal pollination

4.5 PRE- PLANTUMATION OPERATIONS

The late autumn is the best time for planting. In fact, the soil should be prepared in summer when it is temperate. the right soil tillage is chosen based on the result of the two soil samples analysis. If the soil has high active limestone in the lower layer (30-60 cm), it is recommended to drill with a ripper at a depth of 70-80 cm (ripping), leaving the soil profile intact, while if the two analysed layers have uniform results, the soil can be drilled with a single plough by turning over the two layers.

Fertilisation is the first operation to be carried out in preparation for planting: it is appropriate to carry out a deep fertilisation using mature cattle manure (more available), to improve the soil's organic substance and the physical structure of the soil. the quantity of manure used is around 6/7 tonnes per hectare.

In the case of ripping after fertilisation, this is followed by deep ploughing to a depth of 30/40 cm. This practise will allow to bury the residues of any previous crops, and levelling of the ground in order to give the correct slope for water runoff. On the other hand, in the case of ploughing with a monovomer, fertilisation is done before the transplanting bed is levelled.

The soil is broken up and fertilised organically in order to better enable transplanting operations.

Fig. 16 Land plowing

4.6 PLANTUMATION

The optimum time for planting is in autumn (November/December) when the leaves have already fallen and the plants are about to enter their dormant period. If the climatic conditions are not optimal for planting in the autumn, it can be postponed until the end of winter, but it should still be done before germination. One- or two-year-old plants that are of good uniformity, vigorous and have a well-developed root system represent the best planting material. As a general rule, the plants should have a diameter of at least 1 cm and a height of at least 80 cm at the

base, and these can then be trimmed if you opt for a bushy or bushy pot plant breeding.

In order to find plants, it is advisable to contact professional nurserymen who can supply material certified by the legislation for freedom from disease and varietal identity. Plants should never be left bare-rooted out of the soil because they tend to dry out quickly. Seedlings should be planted in holes 20-30 cm deep and wide, which can be dug by hand or with the aid of drills. It is important to be careful when inserting the seedling into the hole. in the case of small tree systems, it is important not to bury the collar of the seedling, which must remain at ground level, in order to avoid an excessive production of suckers, while in the case of policaule systems, the collar must be filled in with fine soil to produce new shoots.

Fig. 17 Frequent mistakes when planting plants

4.7 HAZELNUT GROVE MANAGEMENT

The term 'hazelnut grove management' encompasses all those activities that enable the farm to manage a crop in a controlled manner, such as soil management, fertilisation and pruning.

- SOIL MANAGEMENT

The operations to be carried out are aimed to control the development of weeds in the hazelnut grove and suckers at the base of the plant. These operations differ depending on the fact that they are carried out on young plants that are not yet productive or in hazelnut grove that are in production. On the assumption that the planting of the hazelnut grove was completed at the end of November, the following operations are to be carried out in the years following planting, until the plant comes into production.

- First year:

- Topping and cropping to establish the chosen breeding form;
- Replacement of dead plants;
- 1-2 weeding to control weeds.
- Localised autumn manuring

- Second year:

- Localised spring manuring
- 1-2 Manual weeding around the hazel seedling;
- 2-3 tillage for the control of weeds;
- Possible first manual suckering for monocaole (tree) plantings.
- Localised autumn manuring

- Third and fourthy year:

- Breeding pruning (plant scaffolding);

- Localised spring manuring for underdeveloped plants or scattering for vigorous plants;
- Mulching of infested grasses and soil flattening for mechanised harvesting;
- Manual or chemical suckering;
- Phytosanitary treatments (bedbug, eriophid ...ect). Integrated pest management plan;
- Autumnal spreading manure
- Fifth, seventh year:
- - Production pruning;
- - Spring fertilisation;
- - Cutting in the inter-row and possible weeding in the row for infestation control;
- - Manual or chemical suckering;
- - Necessary phytosanitary treatments (bedbug, eriophid ...ect). Integrated pest management plan;
- - Manual or mechanised harvesting.
- - Autumnal post-harvest fertilisation by scattering.
- Eighth year:
- - Production pruning;
- - Spring fertilisation;
- - Mowing in the inter-row and weeding in the row for weed control;
- - Necessary phytosanitary treatments (bug, eriophid ...ect). Integrated pest management plan;
- - Mechanised harvesting;

- Passage with a two-anchor ripper in the middle of the row to aerate the soil;
- Post-harvest autumn fertilisation by spraying.

➢ FERTILIZATION

The fertilisation is one of the most important agronomic practices in hazelnut cultivation, because it allows the soil to remain fertile, contributes to reducing the phenomenon of alternating production and provides higher yields of good quality. The choice of fertiliser, the quantity and the time of administration are strictly conditioned by the characteristics of the soil, the state of vegetation, the age of the plant, the amount of production and the presence of an irrigation system (fertirrigation). Before applying a fertiliser, as detailed above, it is essential to carry out a chemical-physical analysis of the soil in order to know its characteristics and fertility level. There are different types of fertilisation: basic, breeding and production. The type and quantity of fertilisers to be distributed are different.

It is essential to provide two fertiliser applications, one in autumn and one in spring, for both the development and production phase of the plant. In autumn, it is recommended to use organic and/or mixed organic manure, while in spring complex mineral fertilisers with added microelements can be used. it is best to bury the fertiliser with special buryers or by surface tillage of the soil in order to avoid leaching phenomena. In the case of fertilisation due to physiopathologies, it is appropriate to use fertilisers, but fertirrigation is the best solution for optimise the supply of nutrients to the plants,

➢ PRUNING

Pruning aims to establish a balance between productive and vegetative activity, reducing the phenomenon of alternation and early hazelnut drop. The elimination of excess branches, dry and diseased parts of the plant, allows more light to penetrate the foliage. The hazelnut tree produces on the branches that developed the previous year. Short branches of 5-6 cm are mostly sterile, while for productive purposes the best branches are those of 15-35 cm in length. Various types of pruning can be distinguished: breeding, production, rejuvenation and restoration. Breeding

pruning has the aim to form the plant in relation to the chosen form of cultivation. Production pruning serves to keep the plant balanced and to set up productive branching. The centre of the crown should be emptied, but not too much, so as not to encourage the damage that heavy snowfall could cause. Suckers must be removed, while the crown must be sparse to allow light to pass through. All this leads to the emission of longer twigs on which there is greater fructification. The most suitable period for pruning is winter, between the end of leaf fall and the beginning of female flowering. After pruning, the largest cuts are disinfected by using special mastics and phytosanitary treatments based on copper products. In hazelnut groves in production, it is necessary to make a return cut to stimulate the production of new branches. Sometimes, following heavy snowfalls, extraordinary pruning is necessary, which has nothing to do with the above-mentioned pruning systems. In addition to removing broken branches, the plant's growing form must be reset.

4.8 HARVEST AND STORAGE

Hazelnuts can be harvested in a single step or in repeated steps, as the nuts are gradually ripening. The second solution is preferable in order to avoid fungal attacks on the fruits that remain on the ground for a long time, preventing visible and hidden spoilage of the hazelnuts. Traditionally, the harvesting of hazelnuts was a manual operation that, although time-consuming and inefficient, is still carried out in some Italian regions. This is the case in some areas of Campania and Sicily where the lack of innovation in the plantations, often high density, irregular rows and limited surface areas, limits the use of harvesting machines. In other areas (e.g. terraced hazelnut groves), the high incidence of harvesting costs has often led farmers to abandon this crop. The technology sector can accommodate the needs of the different categories of hazelnut, e.g. by adapting the machines to the different terrain orography and the conditions of use of local realities.

The efficiency of manual harvesting of hazelnuts ranges between 5 and 7 kg/h per operator in young groves, to a maximum of 40/50 kg per die. In medium to large farms and if orographic conditions are not limiting, mechanical harvesting has

almost completely replaced manual one. In the last two decades, technological advancement has made possible the introduction of efficient machines at relatively low costs, ranging between €5,000 and €60,000 for the simplest suction machines up to the most advanced self-propelled ones. Even if the use of mechanisation is not justified by the size of the farm, it may be necessary to make up for the limited availability of labour. The mechanised hazelnut harvest is preceded by the accumulation of hazelnuts in heaps in the middle of the row. This operation can be manual or mechanised using blowers or windrowers. In order to facilitate the windrowing operation, the soil should be compact, well levelled or managed with controlled grassing, appropriately mowed/trimmed before the operation itself. This last operation reduces dust during windrowing and positively influences the performance of self-propelled machines. Blowers, adopted when it is not possible to use windrowing machines, are common both in the Cuneo Langhe and in Sicily. They are carried on the back or driven by tractor power take-offs and produce a jet of air that can be directed by the operator, concentrating the product on the ground at the desired point. The working capacity of mounted blowers is around 6h/ha. Windrowers can be self-propelled or mounted, the former foresee a front working head consisting of two or more brushes with flexible teeth that rotate in the opposite direction and convey the crop to the centre of the inter-row; alternatively, the construction solution foresees a rotor mounted transversally to the machine's forward line and on which the brushes are centred. The mounted windrower consists of a transverse rotor with a horizontal axis carried by the tractor, which also provides the power source. The rotor is fitted with rubber combs, which, as they rotate, place the crop in the swath. Compared to blowers, these machines are more efficient, doubling the operating output. Subsequently, the windrowed product is collected with special pneumatic suction or mechanical pickers whose hourly output varies from 100 kg/h of hazelnuts collected with suction machines, up to 800 kg/h for pickers.

Trailed harvesters work on a line of up to 1.5 m, requiring medium power (35-45 kW), and are suitable for farms of an average surface area of 5 to 10 ha, because they have lower costs and efficiency compared to self-propelled machines. The

capacity of trailed machines varies between 5 and 8 h/ha, depending on the models and characteristics of the hazelnut grove. Nevertheless, they are inefficient in very dense, sloping coril groves without headlands. Self-propelled harvesters operate by mechanically lifting the crop using front-mounted rubber brushes that rotate around a horizontal axis. They are suitable for large extensions because they have a yield of up to 3h/ha (4 t/h). Most of these machines couple the harvesting of the crop with devices for initial cleaning, normally consisting of a ventilation system to remove leaves and empty shells and grids to separate soil and small stones. In the vacuum harvesters, the sucked product is conveyed into a vacuum chamber and then discharged into a conveyor equipped with a side fan that generates a flow of air that transversally strikes the moving product, removing the leaves and lighter impurities mixed with the fruit. Subsequently, the product is conveyed via an auger into a rotating sieve that sorts the nuts. These machines also exploit the air from the suction for dust abatement by means of cyclonic systems that, due to the centrifugal effect, collect solid particles reducing dispersion in the air.

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Fig. 19 Mechanical harvesting

The requirements based on hazelnut quality include shape, shelling yield, moisture, size, peelability and fat content. Hazelnuts present storage problems due to the susceptibility of the fat component to oxidation. A RH (residual humidity) of more than 70% leads to the product resorption of water from the atmosphere, leading to rancidity and/or spoilage. The humidity limit of the kernel, beyond which it loses turgidity and assumes a rubbery consistency, is defined by the 'Critical Water Content', CWC, which is typical for each product. In hazelnuts, the CWC is 9.3%. Higher CWC also corresponds to higher water activity, meaning that it is positively correlated with rancidity and/or spoilage. At too low a RH content, the seeds lose too much weight and become fragile, resulting in easy damage during handling and shelling. Excessive dehydration promotes lipid oxidation. The humidity of the fruit is one of the most important aspects to consider during storage. Like all dried fruit, fungal contamination sees moulds of the genus Aspergillus coming to the forefront. However, due to the low relative humidity content of hazelnuts, 6-7%, mould development is quite rare and is mostly caused by improper storage. In addition to a high RH in the storage environment, causes that favour moulding include: excessive fruit humidity, poor ventilation, inadequate storage temperature, and the presence of insect damage. Hazelnuts can follow different marketing channels:

- Fresh consumption (dried);
- Industrial use (roasted hazelnuts, grain, paste, cream, etc.).

The production of by-products for non-food use, e.g. for biomass energy production, is also of particular importance. Hazelnuts do not require any special pre-conservation practices. The product destined for the fresh consumption market, once dried and sorted, is packaged shelled or unshelled in vacuum-packed bags and displayed at the point of sale. If the product is destined for the industry, once harvested it is sent for dry cleaning and eventual drying, whereby the humidity content is brought below 6%. The cleaning process is carried out to remove the presence of foreign bodies, broken hazelnuts, empty shells and old hazelnuts that are dehydrated. This phase involves the use of fans. The drying of hazelnuts, which lasts 5 to 7 hours (including cooling), is carried out in dryers in which the inlet air temperature varies between 45 ºC and 60 ºC. Higher temperatures are to be avoided

because they can be the cause of undesirable cracking of the fruit. Subsequently, the hazelnuts are roasted and stored at temperatures between 5 ºC and 6 ºC, at a relative humidity of up to 60%.

Hazelnuts can be stored shelled or unshelled, fresh or dried. They are usually stored shelled and semi-dried. They are characterised by a low residual humidity and a very low respiratory activity even at room temperature; so they have an excellent shelf life if properly stored. Storage must be carried out in containers and stacks that allow air recirculation, useful to maintain homogeneous temperature and humidity levels: on average 20-30 recirculations per hour for a minimum of 4-6 hours per day, carried out at regular intervals, are sufficient. Hazelnuts in shell can be stored in the air for 3-4 months at 3-5 ºC and a RH of 50-70% or for 5-6 months under the same humidity conditions, but at lower temperatures (1-2 ºC). For longer storage periods, the use of low-oxygen environments (less than 1%) is recommended. The combination of low temperature with inert gases further extends shelf life, specifically, nitrogen preserves the quality of hazelnuts to a fair level even at 20 ºC. Storage in a controlled atmosphere extends the shelf-life of shelled product up to 14 months if the following conditions are satisfied: RH 55-60%; O_2 less than 1%; CO_2 0-0.3%; N_2 about 99%. Packaged in bags or "big-bags" (bags with a capacity in the order of 500-1000 kg) hazelnuts can be kept under vacuum for 9 months at 3-4 ºC, after flushing with nitrogen and subsequent sealing of the packages. In the case of storage at room temperature, the shelf-life is reduced to 7 months. Shelled hazelnuts can also be stored frozen at -19 ºC for periods of up to 12 months. Among all storage systems examined, the best quality characteristics are ensured by storage in a refrigerated environment and under vacuum.

Fig. 20 Hazelnut dryer

4.9 HAZELNUTS QUALIFICATION

The qualification is the final step to be able to select hazelnuts in terms of quality.

Hazelnut qualification consists of verifying if a lot has the quality to be used in the different purposes, industrial and non-industrial. Therefore, the qualification involves two steps: a first step to identify visible defects and a second step for non-visible defects.

Visible defects are the:

- Ragged;
- Visible blemished;
- Visible damaged.

Non-visible defects are:

- Occult bug;
- Occult damaged

The preliminary stage before analysing the different defects must first be discussed. In order to qualify the hazelnuts, first of all, the hazelnuts of the lot to be qualified must be sampled, then a 2-kg sample is taken and shelled by a shelling machine. After separating the hazelnuts from the shells, the qualification of the defects visible on the outside of the hazelnut can begin.

At the end of the visible defect examination, the hazelnut is examined for damage that is not visible from the outside. In order to be able to view and analyse the inside of the hazelnut, it is necessary that the nuts are opened; this can be done using a cutter machine. The cutter can hold a maximum of 100 hazelnuts, which are crosswise sectioned.

Fig. 21 Shelling machine

Fig. 22 Hazelnut cutter

Finally, the humidity content is measured; this operation is only carried out after shelling, using a humidity meter suitable for nuts.

Fig. 23 Moisture measurement of hazelnuts

FIRST STAGE – IDENTIFICATION OF VISIBLE DIFECTS

- SHRIVELING

Shrivelling is a visible defect due to the lack of water at the time of fruit development.

Fig. 21 Shriveled Hazelnut

- NUT BUG DAMAGE

Visible bug is caused by the bite of the insect both during the fruit's swelling phase and during the ripening of the shell. The visible bug is difficult to recognise as only an experienced and trained eye can see a slight hollow on the nut caused by saliva injected inside the fruit. It is the stylets of the bite apparatus that reach the spongy tissue or the forming seed, causing it to abort traumatically. The bug bites continue even when the hazelnut shell has already hardened and the seed inside occupies the entire fruit cavity.

Fig. 22 Hazelnut attacked by bug - Nut Bug Damage

- VISIBLE DAMAGE

Visible damage is a defect due to fungal attack by organisms that affect the hazelnut under high humidity conditions. These conditions are mainly created when hazelnuts have been on the ground for a long period and have absorbed humidity from the soil. In rainy years, visible damage is one of the most frequent defects found during qualification.

Fig. 23 Visible damage

SECOND PHASE: IDENTIFICATION OF NOT VISIBLE DIFECTS

- OCCULT BUG

Occult bugs are like visible bugs, but during qualification, they are not detected. The saliva that the insect injects by the sting makes some seeds inedible (spoiled taste) and in any case unpalatable to the confectionery industry.

Fig. 24 Occult bug

- OCCULT DAMAGE

Occult damaged is the rottenness of the hazelnut that cannot be recognised during the first stage of qualification but only after the hazelnuts have passed through the cutter are we able to recognise the defect.

Fig. 24 Occult damage

4.10 TECHNICAL AND ECONOMIC ASPECTS

The hazelnut requires lower number of cultivation operations and less labour than other fruit crops. Pruning is less onerous compared to crops such as apple, peach or grapevine, the number of phytosanitary treatments is limited (5-6 per year), and fruit harvesting is mechanised. The management of the hazelnut grove includes a juvenile phase in the first 3-4 years of planting, during which interventions are limited to the elimination of weeds and suckers, to be carried out manually and without the use of chemical products in the first two years, to breeding pruning, fertilisation and phytosanitary treatments as necessary. This phase is mostly unproductive, the first hazelnuts are harvested from the fourth year but the production obtained is modest. From the fifth and up to the eighth year, production increases in quantity, between the eighth and tenth year the hazelnut grove can be considered in the full production phase. The productivity of the hazelnut grove is related to the cultivar, the fertility of the soil, the type of crop management and the presence of irrigation systems. Indicatively, hazelnut yields can range from 15-20 quintals/ha for the less productive varieties and in dry conditions, to 30-35 quintals/ha for the more productive varieties and in irrigated conditions.

The planting costs of the hazelnut grove are estimated at 5,000-7,000 €+VAT/ha and include the costs for soil preparation, basic fertilisation, trimming, the purchase and planting of the plants, as shown in the following tables provided by the Basilicata in Guscio Network, a network of companies that includes all the corilicoli producers who will contribute to Ferrero. Costs vary depending on the area to be planted, the planting system used, which determines the number of plants per hectare, the type of soil and the work required. For an irrigated hazelnut grove an additional expense of 2,000-3,000 €/ha must be added for the irrigation system. The running costs for the adult hazelnut grove are 3,000-4,000 €/ha. Management costs include the purchase of technical means, the cost of labour and agricultural machinery. The costs therefore decrease drastically if the farm is already equipped with the main means for orchard cultivation.

Management of the hazelnut grove performed mechanically and using grassed soil requires 80-100 hours/ha/year of labour, in the case of soil managed by tillage it requires 130-160 hours/ha. First processing also allows a reduction not only in labour hours but also in the cost of non-renewable energy (such as fuel), making it more sustainable.

ANALISI ECONOMICA PER LA REALIZZAZIONE DI UN NOCCIOLETO			1 HA	3 HA	5 HA
	OPERAZIONI PRELIMINARI ANALISI DI FATTIBILITÀ	**note**	**COSTO**	**COSTO**	**COSTO**
1	Verifica attitudine dei terreni RSI, verifica pedo climatica, soprallugo preliminare, verifica variabilità dei suoli ed individuazione punti di campionamento.		€ 280,00	€ 336,00	€ 392,00
	Campionamento terreno, con trivella o profilo del terreno, a 30 e 60 cm * (escavatore a conto dell'imprenditore)	2--4--6	€ 182,00	€ 266,00	€ 364,00
	Trasporto campione presso laboratorio	2--4--6	€ 48,00	€ 84,00	€ 126,00
	Analisi dei componenti di terreno presso laboratorio convenzionato	2--4--6	€ 224,00	€ 448,00	€ 672,00
	TOTALE COSTI OPERAZIONI PRELIMINARI ANALISI DI FATTIBILITÀ		**€ 734,00**	**€ 1.134,00**	**€ 1.554,00**
	OPERAZIONI PRELIMINARI DI IMPIANTO		**COSTO**	**COSTO**	**COSTO**
2	Progettazione planimetria di impianto e calcolo * (per particelle accorpate)		€ 210,00	€ 266,00	€ 322,00
	Predisposizione Piano di concimazione per i primi 3 anni		€ 210,00	€ 294,00	€ 378,00
	TOTALE COSTI OPERAZIONI PRELIMINARI DI IMPIANTO		**€ 420,00**	**€ 560,00**	**€ 700,00**
	PREPARAZIONE DEL TERRENO		**COSTO**	**COSTO**	**COSTO**
3	Rippatura incrociata (2 passaggi) + eventuale aratura a 30 cm		€ 160,00	€ 360,00	€ 702,00
	Eventuale concimazione di fondo		€ 200,00	€ 600,00	€ 1.000,00
	Erpicatura (2 passaggi) e altre operazioni di affinamento		€ 80,00	€ 180,00	€ 351,00
	TOTALE COSTI PREPARAZIONE DEL TERRENO		**€ 440,00**	**€ 1.140,00**	**€ 2.053,00**
	PIANTE E PIANTUMAZIONE SESTO 3X5		**COSTO**	**COSTO**	**COSTO**
4	Squadratura superficie di impianto		€ 250,00	€ 562,50	€ 812,50
	Piantumazione con mezzo meccanico e concimazione		€ 350,00	€ 787,50	€ 1.137,50
	Piantine a radice nuda 667 piantine per *ha* (sesto 5X3)	prezzo pianta € 2,5	€ 1.667,50	€ 5.002,50	€ 8.337,50
	TOTALE COSTI DI PIANTUMAZIONE		**€ 2.267,50**	**€ 6.352,50**	**€ 10.287,50**
	IMPIANTO DI IRRIGAZIONE *		**COSTO**	**COSTO**	**COSTO**
5	Schema idrico impianto di irrigazione, computo metrico e analisi dei campioni di acqua		€ 419,00	€ 550,00	€ 650,00
	Progettazione, Realizzazione e fornitura impianto di irrigazione		€ 2.400,00	€ 6.300,00	€ 9.000,00
	TOTALE COSTI DI IMPIANTO DI IRRIGAZIONE		**€ 2.819,00**	**€ 6.850,00**	**€ 9.650,00**

	RECINZIONE IMPIANTO DI NOCCIOLO		COSTO	COSTO	COSTO
6	Pali in castagno diametro 7/10 h 2,10		€ 500,00	€ 1.350,00	€ 2.125,00
	Rete metallica maglia 8/10 in fero zincato h 1,5 con doppio filo spinato		€ 336,00	€ 907,20	€ 1.428,00
	Messa in opera		€ 320,00	€ 864,00	€ 1.360,00
	TOTALE COSTI DI RECINZIONE		**€ 1.156,00**	**€ 3.121,20**	**€ 4.913,00**

	COSTI PER LA REALIZZAZIONE DELL'IMPIANTO		COSTO	COSTO	COSTO
7	TOTALE OPERAZIONI PRELIMINARI		€ 1.154,00	€ 1.694,00	€ 2.254,00
	TOTALE PREPARAZIONE DEL TERRENO		€ 440,00	€ 1.140,00	€ 2.053,00
	COSTO PIANTE E PIANTUMAZIONE		€ 2.267,50	€ 6.352,50	€ 10.287,50
	COSTO IMPIANTO DI RECINZIONE (realizzato con pali di castagno 7-10 h 2,10 e rete metalicca 8/10)		€ 1.156,00	€ 2.427,60	€ 3.468,00
	TOTALE COSTI DI IMPIANTO DI IRRIGAZIONE		**€ 2.719,00**	**€ 6.789,00**	**€ 9.900,00**
	TOTALE COSTI DI IMPIANTO DI NOCCIOLE		**€ 7.736,50**	**€ 18.403,10**	**€ 27.962,50**

Costo per ha	**€ 7.736,50**	**€ 6.134,37**	**€ 5.592,50**

COSTI ANNUALI DI GESTIONE DELL' IMPIANTO

	COSTI DI GESTIONE 1 - 3 ANNO	COSTO	COSTO	COSTO
8	Controllo infestanti (2 erpicature al mese per 6 mesi)	€ 230,00	€ 552,00	€ 517,50
	Trattamento fitosanitario	€ 355,00	€ 1.065,00	€ 1.775,00
	Potatura, cimatura e spollonatura	€ 140,00	€ 420,00	€ 700,00
	Irrigazione	€ 323,00	€ 775,20	€ 1.211,25
	Assistenza Agronomica 3 visite annue** (ad ettaro e per distanza)	€ 120,00	€ 120,00	€ 120,00
	TOTALE COSTI 1-3 ANNO	**€ 1.168,00**	**€ 2.932,20**	**€ 4.323,75**
	costo ha	**€ 1.168,00**	**€ 977,40**	**€ 864,75**

	COSTI DI GESTIONE 4 ANNO	COSTO	COSTO	COSTO
9	Diserbo (1 trinciatura x mese x 4 mesi + 2 trattamenti interf. + spollonatura)	€ 230,00	€ 552,00	€ 517,50
	Trattamento fitosanitario	€ 435,00	€ 1.305,00	€ 2.175,00
	Potatura	€ 140,00	€ 420,00	€ 700,00
	Irrigazione	€ 323,00	€ 969,00	€ 1.615,00
	Raccolta manuale- andanatura pneumatica-trasporto	€ 100,00	€ 300,00	€ 500,00
	TOTALE COSTI 4 ANNO	**€ 1.228,00**	**€ 3.546,00**	**€ 5.507,50**
	costo ha	**€ 1.228,00**	**€ 1.182,00**	**€ 1.101,50**

	COSTI DI GESTIONE 5 ANNO	COSTO	COSTO	COSTO
10	Diserbo (1 trinciatura x mese x 4 mesi + 2 trattamenti interf. + spollonatura	€ 230,00	€ 552,00	€ 517,50
	Trattamento fitosanitario	€ 435,00	€ 1.305,00	€ 2.175,00
	Potatura	€ 140,00	€ 420,00	€ 700,00
	Irrigazione	€ 323,00	€ 969,00	€ 1.615,00
	Raccolta manuale- andanatura pneumatica-trasporto	€ 150,00	€ 450,00	€ 750,00
	TOTALE COSTI 5 ANNO	**€ 1.278,00**	**€ 3.696,00**	**€ 5.757,50**
	costo ha	**€ 1.278,00**	**€ 1.232,00**	**€ 1.151,50**

	COSTI DI GESTIONE 6 ANNO	COSTO	COSTO	COSTO
11	Diserbo (1 trinciatura x mese x 4 mesi + 2 trattamenti interf. + spollonatura	€ 230,00	€ 552,00	€ 517,50
	Trattamento fitosanitario	€ 435,00	€ 1.305,00	€ 2.175,00
	Potatura	€ 140,00	€ 420,00	€ 700,00
	Irrigazione	€ 323,00	€ 969,00	€ 1.615,00
	Raccolta manuale- andanatura pneumatica-trasporto	€ 350,00	€ 1.050,00	€ 1.750,00
	TOTALE COSTI 6 ANNO	**€ 1.478,00**	**€ 4.296,00**	**€ 6.757,50**
	costo ha	**€ 1.478,00**	**€ 1.432,00**	**€ 1.351,50**

	COSTI DI GESTIONE 7 ANNO In poi	COSTO	COSTO	COSTO
12	Diserbo (1 trinciatura x mese x 4 mesi + 2 trattamenti interf. + spollonatura	€ 230,00	€ 552,00	€ 517,50
	Trattamento fitosanitario	€ 435,00	€ 1.305,00	€ 2.175,00
	Potatura	€ 140,00	€ 420,00	€ 2.175,00
	Irrigazione	€ 323,00	€ 969,00	€ 2.175,00
	Raccolta meccanizzata	€ 350,00	€ 1.050,00	€ 2.175,00
	TOTALE COSTI 7 ANNO In poi	**€ 1.478,00**	**€ 4.296,00**	**€ 6.757,50**
	costo ha	**€ 1.478,00**	**€ 1.432,00**	**€ 1.351,50**

PRODUZIONE LORDA VENDIBILE (PREZZO MEDIO ULTIMI 5 ANNI € 3,15)				
SESTO 3X5 - PIANTE PER HA 667 ESTENSION 1HA				
	KG/ ettaro	ricavi	costi di gestione	MOL
ANNO 1	€ 0,00	€ 0,00	€ 1.168,00	-€ 1.168,00
ANNO 2	€ 0,00	€ 0,00	€ 1.168,00	-€ 1.168,00
ANNO 3	€ 0,00	€ 0,00	€ 1.168,00	-€ 1.168,00
ANNO 4	€ 0,00	€ 0,00	€ 1.228,00	-€ 1.228,00
ANNO 5	€ 293,48	€ 924,46	€ 1.278,00	-€ 353,54
ANNO 6	€ 660,33	€ 2.080,04	€ 1.478,00	€ 602,04
ANNO 7	€ 1.467,40	€ 4.622,31	€ 1.970,00	€ 2.652,31
ANNO 8	€ 1.907,62	€ 6.009,00	€ 1.970,00	€ 4.039,00
ANNO 9	€ 2.494,58	€ 7.857,93	€ 1.970,00	€ 5.887,93
ANNO 10	€ 2.788,06	€ 8.782,39	€ 1.970,00	**€ 6.812,39**

ESEMPIO PLV 10 ANNO	
Plv= € 3,15/kg x 2.788 kg	€ 8.782,20
Costi di gestione al 10 anno	€ 1.970,00
MARGINE OPERATIVO LORDO	**€ 6.812,20**

PRODUZIONE LORDA VENDIBILE (PREZZO MEDIO ULTIMI 10 ANNI € 2,49)					
SESTO 3X5 - PIANTE PER HA 667 ESTENSION 1HA					
	KG/pianta	KG/ ettaro	ricavi	costi di gestione	MOL
ANNO 1	0	0	€ 0,00	€ 1.168,00	-€ 1.168,00
ANNO 2	0	0	€ 0,00	€ 1.168,00	-€ 1.168,00
ANNO 3	0	0	€ 0,00	€ 1.168,00	-€ 1.168,00
ANNO 4	0	0	€ 0,00	€ 1.228,00	-€ 1.228,00
ANNO 5	0,44	293	€ 730,77	€ 1.278,00	-€ 547,23
ANNO 6	0,99	660	€ 1.644,22	€ 1.478,00	€ 166,22
ANNO 7	2,2	1.467	€ 3.653,83	€ 1.970,00	€ 1.683,83
ANNO 8	2,86	1.908	€ 4.749,97	€ 1.970,00	€ 2.779,97
ANNO 9	3,74	2.495	€ 6.211,50	€ 1.970,00	€ 4.241,50
ANNO 10	4,18	2.788	€ 6.942,27	€ 1.970,00	**€ 4.972,27**

ESEMPIO PLV 10 ANNO	
Prezzo medio in guscio Tonda di Giffoni ultime **10 campagne**	€ 2,49 kg
Plv= € 2,49/kg x 2.788 kg	€ 6.942,12
Costi di gestione al 10 anno	€ 1.970,00
Margine operativo lordo	**€ 4.972,12**

Tab. 2 Economic analysis for the realization of a hazelnut grove

5. IMPLEMENTATION OF A MIXED AGROFORESTRY SYSTEM

Torralba M. et al., (2016) reported that the European biodiversity is connected to the agroforestry system. In addition, agroforestry practices have a fundamental role in the conservation of biodiversity, in fact, if conducted and designed in a sustainable manner (Freschi P. et al., 2015) can provide several benefits such as:

- to reduce the use of pesticides

- to increase agricultural crop yield

- to diversify agricultural income

- to reduce soil erosion

- to improve water quality and water saving (Angima S. D. 2009; Cosentino C. et al., 2015).

This is particularly evident for pastures, the correct implementation can positively influence the botanic and faunal biodiversity (Rook A. J. and Tallowin J. R.; 2003; Tallowin J. R. et al., 2005; Freschi P. et al., 2015 a).

Several studies have reported that moderate levels of grazing are significant contributors to the richness, to the diversity of plants and invertebrates that subsequently support native fauna. Among a species listed as threatened and undergoing genetic erosion or extinction (Freschi P. et al., 2015 a), (Mohammed K. A. F. et al., 2013).

Other positive aspects are the improvement of agricultural soil fertility, disease prevention, pest control, agricultural diversity, environmental sustainability, agricultural diversification and multifunctionality, and increased farm income (Sossidou E. N. et al., 2011; Liu M. et al., 2013).

In an agroforestry system, woody perennial plants (trees or shrubs) are integrated on the same unit of land with crops and/or livestock in order to optimise positive interactions between wood and other components (Nair P. R., 1993). The above advantages of raising livestock in a mixed system are particularly evident O'Brian J. et al., 2006; Stobbelaar D. J. and Hendriks K., 2011; Smith J. et al., 2013).

However, when talking about silvopastoral systems, animal husbandry in the fruit groves must also be taken into account.

In Italy, the most common practice is intercropping sheep under olive trees, a technique that we find described already by Lucius Junius Moderatus Columella (4-70 AD) in 'De re rustica'. In recent years, the decrease of profits in olive production and the obligation to conserve natural resources have allowed the re-discovery of olive land management (Paris et al. 2019; Pisanelli et al. 2018). The application of all the new knowledge has also led to the conception of new intercropping systems, such as olive and hazelnut grove (Rosati et al. 2012).

Therefore, an interesting approach is to integrate goat grazing within agroforestry systems of high value fruit trees, cherry trees and/or production of walnuts, almonds, chestnuts, apples and pears.

An additional source of indirect income (decrease in processing costs) can be attributed to pest control and fertilisation by grazing animals, as well as reducing the impact of production processes in terms of carbon footprint

5.1 THE FRISA GOAT OR FACCIUATA LUCANA

- **Origin and spread**

The Frontalasca[2] race (or Frisa Valtellinese) is native to Frontale in Val di Rezzalo (Valtellina Lombardy).
It is of a similar strain to the Grigionese. It is bred throughout Valtellina, Val Malenco, Val Masino and Valchiavenna. The breed registry was activated in 1997.

The predominant use is meat production due to its considerable size, high twinnability, good maternal disposition, high live weight at birth and good goat growth. It is used for the production of Violino, a traditional ham from Valtellina and Valchiavenna, which is obtained by curing the shoulder and thigh. Milk production is also very good.

- **Morphological features**

Size: large, robust and well-proportioned.

Head: Front-nasal profile straight, ears set to the side with white shading. Horns carried back in scimitar shape (there are also acorns).

Trunk: long but strong neck, with or without canopies. Long thorax with straight back-lumbar line; croup averagely sloping and well developed. Solid limbs.

Fur: black, with characteristic white streaks on the sides of the head, belly, undertail and extremities of the limbs. Coat: medium length, thick and glossy. Fine, elastic skin.

Average height at withers:

- Females a. cm. 78
- Males. cm. 75 – 85

Average milk production:

- Primipare lt. 210
- Pluriparous lt. 396

[2] https://www.agraria.org/caprini/frontalasca.htm

The Frisa Lucana Goat

The southern livestock sector is affected, more than other sectors, by the constraints of the past, by international restrictions, by its own limitations and by the development policies implemented especially in the post-war period.

The goat breeding can be considered a prototype of this reality. it has been considered from time to time the 'poor man's cow', the destroyer of forests, the desertification of the land. Anyway, it expresses among the animals of zootechnical interest, the lowest level and rate of development but the highest potential. Autochthonous genetic types, milk and its organoleptic and dietetic qualities constitute a heritage of endogenous resources that can and must be valorised.

In Basilicata Region, there are several goat genotypes that deserve consideration and should certainly receive more attention by those working in the sector.

These are genotypes that breeder in the past had selected from their own territories. They are particularly suited to the environments, to the systems and territory where they had been selected, endowed with good fertility, prolificacy, possessing both excellent daily milk production and excellent rusticity.

In this context, an interesting genotype, now considered almost lost, is the Capra Frisa Lucana called ' la facciuta'.

In the past, this breed was present in medium and small farms in the interior of the northern Ionian area. Today, however, the presence of this breed is limited to a few individuals reared at the stake, i.e. one or two individuals connected to a more or less long rope fixed to the ground with a 35-40 cm stake, where the length of the rope represents the possibility of movement and/or limits the grazing area.

The productions of these genotypes are particularly interesting due to the fact that they are capable of producing 2.5-3 kg of milk per day, and have an excellent capacity to adapt to the Lucanian territory.

In an attempt to safeguard these endangered breeds, goat herds of the mixed breed population are raised, which bear the fruit of 'unconsidered' crosses that are useful in a way. In fact, through a programmed reproduction followed by selection, it could

be the basis for the recovery and/or training of breeds that are certainly hardy, suited to the harshness of the Lucanian territory, and endowed with good production capacities, in terms of both quality and quantity.

Fig. 25 The Frisa Lucana Goat

5.2 STUDY AREA

The study was carried out in a Corylus avellana field (hazelnut grove), cultivar 'Tonda di Giffoni', and 5x3 planting size, located in Basilicata.

The area of the site (40°22'43.33 "N- 16° 8'47.73 "E) is approximately 2 ha and is located at 901 - 910 m a.s.l., in the countryside of Guardia Perticara (PZ).

Fig. 26 Viola Farm Location-hazelnut grove

The farm is located in an area of good potential for hazelnut cultivation.

The farm is located in an aptitude class S3 100%, as shown in the map for coril cultivation of the Basilicata Region[3], that is a class where the cultivation is successful, as it was in real.

The factors restricting this suitability class are texture, slope altitude, internal drainage, AWC (Available Water Capacity in the soil) minimum temperature.

The farm is part of a macro area where the main soils are:

- Le Serre Soil: clayey on the surface, clayey-sandy in depth. Deep, with no or little skeleton, very calcareous, sometimes moderately calcareous on the

[3] https://rsdi.regione.basilicata.it/viewGis/?project=D6ADDE7A-565C-5747-2577-136186FE73E5

surface. They have an alkaline reaction on the surface, moderate low permeability and good drainage, but sometimes mediocre.

- Montepiano Soil: moderately deep or deep, limited by low altered rock. They have a loamy texture, and scarce or common skeleton. They are generally carbonate-free, sometimes poorly calcareous. Neutral on the surface, they are sub-alkaline at depth, and have high base saturation. Their drainage is good.

From an orographical point of view, the area is located in zones with moderate to very steep mountainous relief, often interrupted by steep slopes of a tectonic nature, at the base of which lie low-lying areas with a gentler slope. The altitudes are between 100 and 1,100 m a.s.l. Most of the land utilisation is pasture and forests, with subordinate agricultural areas.

In this zone, we have cold requirements needed for flowering that is far beyond the minimum values ranging from 1,074.6 - to 1,512.9, while late frosts have low return values of around 20 %.

Inside the farm's corral, 10 goats grazed during the lactation period. The pasture was delimited by electrified net to avoid goats to eat the hazelnuts as well. Goat grazing has significantly reduced the use of mechanical means for weed control, reducing management costs. In particular, there has been an improvement in soil quality.

Fig. 27 Goats grazing in the hazelnut grove

5.3 HAZELNUT PERISPERM

The perisperm (or perispermis), the term derived from peri and σπέρμα 'seed'. In botany, it is nutritive tissue of a seed derived from the nucellus and deposited external to the embryo sac —distinguished from endosperm. The perisperm is therefore the nutrient complex that replaces the albumen in the seed of some plants.

The perisperm is located in the seeds in certain plants alone, e.g. in caryophyllaceae, or together with the endosperm, e.g. in nymphaeaceae and piperaceae; it may be located outside or one side of the normal albumen (secondary endosperm)[4].

Concerning the formation of the hazelnut perisperm, attention must be focused on its fructification cycle.

[4] https://www.actaplantarum.org/glossario/glossario_view.php?id=2342

Hazel is a monoecious and dicline species, i.e. it bears female and male flowers on the same plant, which have different maturation and development periods.

The fruiting cycle of the hazel tree begins with flower induction and differentiation of the flower organs. These processes start in May and June, first for the male inflorescences and then for the mixed buds containing female flowers. After induction, the flower buds differentiate the flower organs.

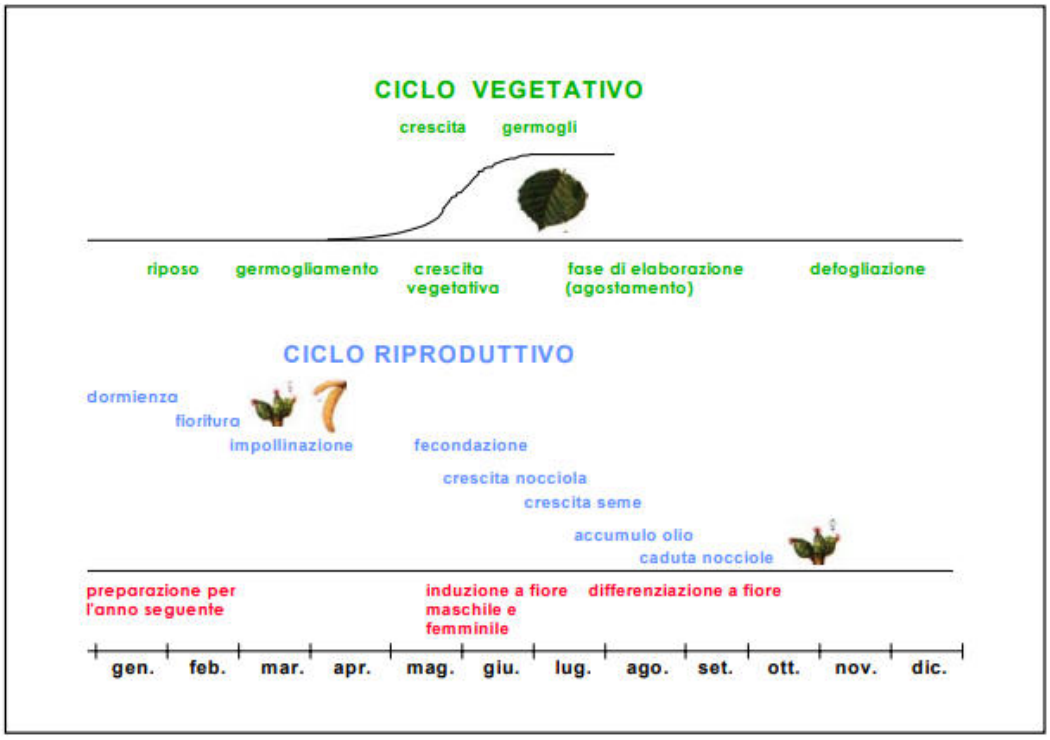

Fig. 28 Annual biological cycle of the hazelnut tree (Bignami et al., 1999).

After fertilisation, the fruit starts an active development, reaching their final size within a month; however, the tissues are very rich in water and have a low dry matter content. In fact, they increase their dry weight from the end of June until harvest in a continuous and constant manner. Meanwhile, the seed increases its weight later; the weight increase begins to be substantial from the end of July to harvest.

This means that at first stage, the fruit grows in size, then it consolidates the structure and consistency of the shell, and finally it completes the seed. In particular, the hazelnut shows a sigmoidal curve and three different periods of

development in both seed and fruit: a first stage from fertilisation to the 4-5 weeks; a second stage from the 5th to the 12th week of development, and the final stage from the 14th week until complete development.

The fruits consist of the shell in the proportion of 50-60% and the seed in the proportion of 40-50% at complete maturity. Of course this percetange is higlhy depending on the cultivar and cultivation conditions (Tombesi, 1985).

The seedless hazelnuts fall before the maturity period with their shells; the same happens for empty infructescence. In the worst scenarios, production losses can reach 80-90% (Ribaldi, 1968). Several causes have been hypothesised to explain this phenomenon: insufficient pollination cannot be responsible for the production of seedless fruit, since an unpollinated flower never reaches the size of an empty nut (Thompson, 1967). However, the percentage of seedless fruit depends on the type of pollinators (Zielinski and Thompson, 1966) and is a varietal characteristic (Painter, 1956). Dimoulas (1979) showed that the number of fertilised ovules per hazelnut has a great influence on the formation of certain types of seedless fruit. This phenomenon depends on the aptitude or not of the variety to give double-seeded fruit.

Some growing practices seem to influence the amount of hollows: strongly pruned trees have a lower incidence than unpruned ones; a water deficit may be linked to a high degree of hollows. In addition, this incidence can be influenced by soil type (Painter, 1960), and in particular, the availability of potassium that seems to reduce the number of voids (Painter and Hariman, 1958). In addition to genetic and cultural factors, climatic parameters also play a major role in these phenomena. In fact, Ribaldi (1968) observed that low temperatures and high rainfall during fertilisation were linked to a high percentage of voids.

All this aspect (delayed harvest, incorrect storage and climatic factors) can maybe influence the nutritional values and compositional characteristics of hazelnuts.

Nutritional value of fresh hazelnut consumption depends largely on the oil content of the kernel and has been extensively investigated and established (Richardson et al., 1997). The lipids affect the quality of hazelnuts during storage, and the

confectionery products made from them (Garrone et al., 1994). The fat content varies from 62% to 70% of the dry weight of the kernel, with variations between cultivars. Oleic acid is the main fatty acid contained in the lipid fraction, followed by linoleic acid, palmitic acid and stearic acid; these four fatty acids together account for more than 95 % of the total lipids (Soliva et al., 1983; Arcoleo, 1991; Parcerisa et al., 1999; Bignami et al., 2005). There are also a number of acids present in very small quantities such as lauric, myristic, myristoleic, pentadecanoic, pentadecenoic, palmitoleic, heptadecanoic, heptadecenoic, linolenic, arachic, eicosadienoic and eicosatrienoic, behenic and lignoceric acids (Lotti et al., 1985; Contini et al., 1994; Bignami et al., 2002).

The balanced polyunsaturated fatty acid content and the presence of compounds with antioxidant properties give hazelnuts an important role in human nutrition. In fact, research has shown that hazelnuts contain substances that can exert a strong protective effect against atherosclerosis, coronary heart attack, certain cancers and other vascular diseases (Arlorio et al., 1996; Richardson, 1997). The lipid compounds that have been shown to have beneficial health effects are vitamin E (α-tocopherol) for its antioxidant properties, present in quantities of 25-50 mg per 100 g of cold-pressed hazelnut oil (Ozdemir et al., 2000; Giusti et al., 2002; Bignami et al, 2005), vitamin B6 (Leklem, 1991), unsaturated fatty acids (mainly oleic acid), and sterols, in particular β-sitosterol, which is present in amounts close to 150 μg per g hazelnut oil (Savage et al., 1999; Giusti et al., 2002) and is involved in the reduction of blood cholesterol (Richardson, 1997). In this context, it has been shown that the consumption of approximately 25 g hazelnuts allows the assimilation of 100 % of the recommended daily allowance (RDA) of vitamin E, as well as 25 % of the RDA of vitamin B6, with positive repercussions on maintaining good health (Koyuncu et al, 1997; Salas-Salvadò et al., 2005).

We should remember that a high linoleic acid content in the lipid fraction of the hazelnut is the main cause of auto-oxidation in the kernel (Bonvehi et al., 1993). Cultivars containing a low percentage of total linoleic acid are more suitable for long periods of preservation and storage. In particular, the occurrence of undesirable flavours during storage is mainly due to lipid oxidation (Fourie et

Basson, 1989), which involves the breakdown of unsaturated fatty acids. This can be delayed by the presence of natural antioxidants in the oil such as tocopherols that can preserve the fats from rancidity; ensuring hazelnuts can be stored for several months (Ebrahem et al., 1994). However, due to their great nutritional value, polyunsaturated fatty acids, which are easily digestible and particularly valuable in reducing blood cholesterol, can be consumed in greater quantities through fresh consumption of hazelnuts from cultivars that are less suitable for long storage periods (Salas-Salvadò et al., 2005).

Various studies have been conducted on the lipid fraction of hazelnuts, few bibliographic data are currently available on the minor components, such as sugars, organic acids, and minerals (Botta et al., 1994; Bignami et al., 2002). The sugar content has values of about 4 % of dry weight of the seed. The most soluble sugars present are sucrose, accounting for 80% of the total sugars, followed by stachyose and raffinose with 6% and 3% respectively (Botta et al., 1997; Bignami et al., 2005). Glucose, fructose and inositol are present in low amounts (50-400 μg/g p.s.).

The sucrose present in the seed contributes to the composition of the hazelnut, and a high content can be a significant discriminating factor in taste tests (Botta et al., 1994; Richardson et al., 1994). Stachyose and raffinose are hydrolysed during germination to form sucrose. Their presence, however, does not seem to influence the sweetness of the seed (Botta et al., 1994; Richardson et al., 1994). Among the organic acids, the most representative is malic acid, with contents ranging from 0.5 to 2 mg/g dry weight. There are also other acids, such as succinic, galacturonic, citric, acetic, butyric and levulinic, present in very small quantities (Botta et al., 1994; Richardson et al., 1994; Bignami et al., 2005). Among the minor components, there is starch at 1-2% of the dry weight of the hazelnut kernel (Giusti et al., 2002). In terms of protide content, which belong almost entirely to the globulin group, their value does not differ from 15% with the exception of the Tonda di Giffoni and San Giovanni cultivars, with 12.5% and 16.7%, respectively (Miuccio et al., 1968).

Amino acids were found to be 16. Among them, lysine and methionine were found to be low, while arginine, glutamic acid and aspartic acid were found to be high (Fang et Butts, 1950). Serra Bonvehi et al. (1995) showed a higher protide content in hazelnuts of Spanish cultivars grown under irrigation, highlighting the content of 85% albumin and globulins. The hazelnut is also a good source of minerals, such as iron, magnesium, calcium and zinc, and contains good amounts of potassium and a low level of sodium, which promotes regular blood pressure (Pala et al., 1996). Furthermore, metals such as copper, iron and manganese play an important role in the biosynthesis of linoleic acid (Marschner, 1986).

Several studies report on the chemical composition of hazelnut kernels, but very few concern the characterisation of the nut albumen. The lack of interest in this part of the kernel is due to the fact that it is generally considered a waste product, despite the fact that a small amount often becomes part of processed hazelnut products, due to the difficulty of its separation from the edible part.

However, some studies have highlighted the presence of chemical components that can contribute to determine or preserve the quality of the seed. In fact, a high concentration of polyphenols has been found in the hazelnut perisperm (Andreoni, 1997) while its antioxidant capacity during storage ensures product stability (Ghirardello et al., 2013).

Polyphenols, chemical components derived from the secondary metabolism of plants, are widely distributed in the plant and can provide multiple functions, depending on the compound.

It can be highlighted that the regular consumption of certain foods and beverages, including small red fruits, apples, red wine, tea, and coffee associated with a consumption of other fruits and vegetables, plays an essential role in determining the higher or lower amount of polyphenolic antioxidants in the occidental diet. The use of roasted hazelnut perisperm in the production of yogurt resulted in an increase in polyphenol content and antioxidant capacity (Zeppa et al., 2013).

Research on the intake of hazelnut perisperm in animal feed is scarce. Boccignone M., 1976, analysed the possible use of waste food industry in animal feed by

observing the chemical and chromatological composition of the perisperm of roasted hazelnuts. Other researchers have used perisperm as in the diet of cows to assess its suitability for feeding (Renna M., et al 2020) and of sheep to evaluate its sensory effect in cheese (Caccamo M., et al 2019).

In the present research, hazelnut perisperm was used as an addition to the goats' feed ration in the milking parlour as well as to refine the cheese produced in the maturation process by adding Marsala and Grappa. The tests performed were evaluated by Consumer Test for preference. Similar tests have been done using salami from pigs raised using a diet integrated with hazelnut perisperm (Menci R., 2018)

Fig. 28 Hazelnut perisperm

5.4 INTEGRATION INTO THE MILKING PARLOR

The types of forages for goat feeding are varied, from pasture to concentrates supplements to provide quality milk production.

Forages can be found in different forms with their advantages and disadvantages:

- Straw: cheap (in the flatlands), poor food supply;
- Grass silage: alternative to haymaking, high quality to avoid health risks (listeriosis);
- Silage Maize: cheap (in the flatlands), high quality to avoid health risks (listeriosis);
- Pasture: Economical, suitable pasture areas, constant labour;
- Gramineae grasses: dry fodder base, not always of high quality;
- Medica grasses: fodder base in lactation, not always of high quality;
- Ventilated Hay: alternative to haymaking and difficult to find on the market;
- Dehydrated Hays: Constant quality but only valorised with a unifeed; Health risks (clostridiosis).

The concentrates:

- Commercial feed: Convenience, minimal supplementation, with a single formula adapted to the different physiological states of the goat
- Feed + raw materials: Convenient, minimal supplementation, adapted to the different physiological states of the goat
- Commercial raw material mixture: Cost-effectiveness, possible mixing errors, integrator supply

MAJOR ENERGY SOURCES (CEREALS):

Immediate use (fermentation of the starch in the rumen)

- Wheat > Triticale > Barley > Oats > Corn> Sorghum
- Flaked> Rolled> Flour> Entire grains

THE MAIN PROTEIN SOURCES (PROTEAGINOSE): Speed of use (nitrogen degradation in the rumen)

- Flaked > Toasted > Extruded > Flour Extraction > Raw Seeds

Protein Supply

- Whole Seeds / Flours Extraction: Soya > Flax > Protein Pea > Cotton > Sunflower

Lipid Content

- Whole Seeds: Sunflower > Flax > Soya > Cotton

In the specific case of this PhD project, the Viola farm implements a semi-extensive farming system for sheep and goats. During the colder months, from November to March, the animals are kept in stables to protect themselves from the cold temperatures. In the summer season, on the other hand, the animals are led to pasture, in vast pastures rich in grass where they can move freely. The feed of the sheep and goats consists of grasses for the months when they remain in the pasture and, in the winter, in the barn, of about 60 per cent grass forage and about 40 per cent cereals and legumes, produced on the farm.

During the lactation period, about 20 % hazelnut perisperm was fed in the daily ration (800 g/day mixture of oats, peas, toasted flakes, feed) for 15 consecutive days.

Fig. 29 Integration into the milking parlor

6. MATERIALS AND METHODS

6.1. MILK AND PERISPERM ANALYSIS

Goat milk samples were collected at the Viola farm by mechanical milking, refrigerated at 4°C and immediately transported to the laboratory for analytical determinations. Values of pH (using pH meter HI931410, Hanna Instruments, Padua, Italy), protein, fat and lactose were measured according to the standard parameters of the International Dairy Industry Federation FIL IDF 141 C (ISO, 2013a).

In addition, the following parameters were evaluated: total viable bacteria count (ISO, 2013b) performed on agar; somatic cells (IDF 148-2:2006); freezing point (IDF 108:2009).

The following table shows the main characteristics of goat's milk used for cheese production.

Parameters	Goat Milk
Dry matter, *g/100g*	13.5
Ashes, *g/100g*	0.70
Fat, *g/100g*	4.50
Protein, *g/100g*	4.10
Lactose, *g/100g*	4.65
Somatic cells, *cellule/ml*	410,000
Bacterial count, *UFC/ml*	546,000
Inhibitor search	absent
Freezing point, *mC*	-550
pH, *u-pH*	6.55

Tab.3 Milk analysis

The hazelnut shelling and qualifying actions determine the production of a by-product with high qualities called hazelnut perisperm. Samples of hazelnut prisperm with the following composition were collected during shelling and cleaning actions: crude protein (Kijeldal method) 9.0 g/100 g, crude fibre (NIR) 19.0 g/100 g, ether extract (NIR) 15.1 g/100 g.

Perisperma Nocciole

Data Accettazione : 17-09-21 Ora : 12:14 Consegnato Da : Cliente dott. Cosentino

Prelievo Data/Ora : 10-09-21 Da : Cliente dott. Cosentino

Luogo prelievo : /

Modalità prelievo : Effettuato dal Cliente

Data Inizio Analisi : 17-09-21 Data Fine Analisi : 21-09-21 Sigillo : No

Descrizione Analisi	Metodo	Risultato	u.m.
Sostanza secca	N.I.R.	93,3	%peso
Proteina grezza	N.I.R.	2,4	%peso
Estratto etereo	N.I.R.	10,5	%peso
Fibra grezza	N.I.R.	7,6	%peso
Fibra al Detergente Acido	N.I.R.	14,5	%peso
Lignina Acido-Detergente	N.I.R.	6,0	%peso
NDF	N.I.R.	21,0	%peso

Fig.30 Perisperm analysis

6.2 NEW CHEESE PRODUCT - PRODUCTION OF CHEESE REFINED IN HAZELNUT PERISPERM

The collected goat milk was heat-treated by pasteurisation at 65°C for 15 minutes and then cooled to 34°C. It was inoculated at 42°C with lyophilised lactic acid bacteria starter cultures of Lactococcus lactis subsp. lactis and Streptococcus thermophilus (6 g/hL; FL 058, Prodor, Piacenza, Italy). After a 15-min, calf rennet (activity 1:10000; chymosin/pepsin 80:20; Santamaria Srl, Burago di Molgora, Italy) was added in the amount of 1 ml in 10 L of milk.

After a 30 minutes of coagulation, the 1 cm curd was broken. After resting under the serum for 10 minutes, the curd was collected and pressed into perforated moulds. The cheeses in the moulds were placed in a steaming vat at 25-27 °C at pH < 5.20 for 10 hours.

Once the cheese had been drained, it was turned over using slight dry salting (2-3% NaCl, pH 5.20) on one side and then turned over with salt on the other side.

Moulds were produce in numer of 10 with the weigh of 500 gr each one.

Fig 31 - Cheesemaking trials (1. Milk Pasteurization of; 2. Starter addition; 3. Rennet addition)

Fig 32 - Cheesemaking trials (1. pH measurement; 2. Curd breaking; 3. modls).

The moulds produced were divided into two groups A and B. A mixture of hazelnut perisperm and grappa was applied to group A; a mixture of hazelnut perisperm and marsala was applied to group B. The cheese was ripened for 30 days in a maturation room at a temperature of 10°C and 70% relative humidity.

The pictures below illustrate the two cheeses produced:

- Sample A: goat's cheese with the addition of a mixture of hazelnut perisperm and grappa;
- Sample B: goat's cheese with the addition of a mixture of hazelnut perisperm and marsala

Fig. 33 Goat cheese with a mixture of hazelnut perisperm and grappa (A).

Fig. 34 – Goat cheese with a mixture of hazelnut perisperm and grappa (B).

The experimental procedure was carried out in duplicate using the same protocol in order to avoid the environmental effect.

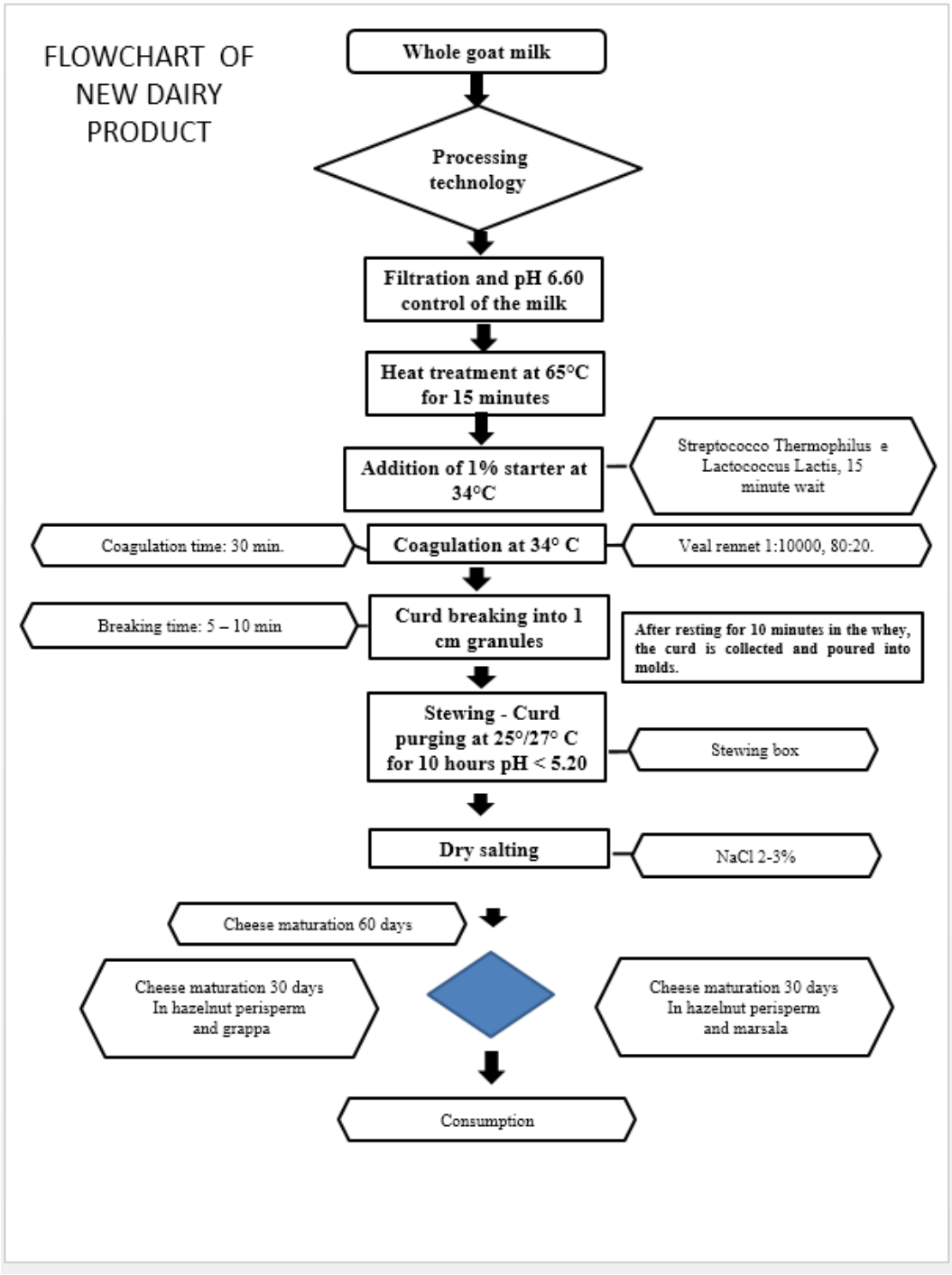

Fig. 35 – Flowchart of new dairy product

6.3 CONSUMER TEST

The acceptance of cheeses refined in a mixture of hazelnut perisperm and grappa or marsala was evaluated by 47 habitual cheese consumers (58% male and 42% female, age 25-51 years). The consumers were recruited at the University of Basilicata Campus. A short training session was conducted before the consumer test in order to make the consumers familiar with the descriptors, but they did not receive any information regarding the experimental design. In addition, at each consumer was asked to evaluate the described sensory parameters and to use water and unsalted crackers at their disposal.

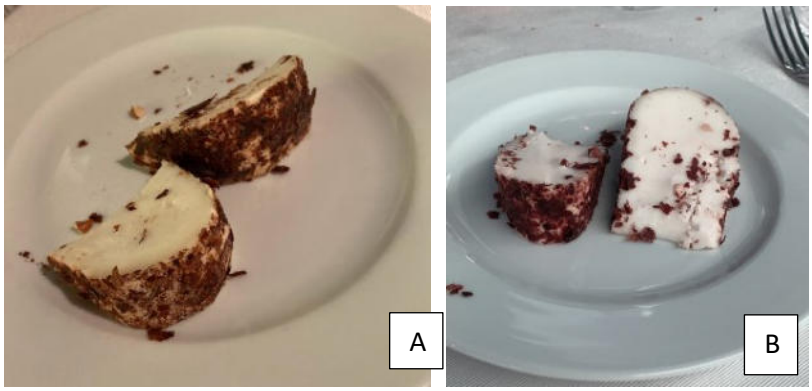

Fig. 36 – Goat cheese with a mixture of hazelnut perisperm grappa (B). (A) and marsala (B).

The fresh hazelnut goat cheese produced in the varieties refined in grappa and marsala (A and B), was divided into 20-gram pieces, coded with a 3-digit series, taken to room temperature for 1 hour, and then served randomly under a fluorescent light to consumers together with the sensory evaluation survey. Consumers were asked to rate the following sensory parameters: colour, odour, flavour, texture and overall judgement, using a 9-point liking scale (1 = extremely unpleasant, 2 = quite unpleasant, 3 = moderately unpleasant, 4 = slightly unpleasant, 5 = neither unpleasant nor pleasant, 6 = slightly pleasant, 7 = moderately pleasant, 8 = quite pleasant, 9 = extremely pleasant). The consumer test was carried out in individual cabins.

Statistical Analysis

The data were evaluated by One-WAY ANOVA, and the averages were compared with Tukey's HSD (honestly significant difference).

6.4 ELECTRONIC NOSE ANALYSIS

The electronic nose is an appropriate pattern recognition system capable of recognizing simple or complex odors. It is a biomimetic system, designed to mimic the functioning of olfactory systems present in nature such as that of mammals or more specifically the human one. The electronic nose, like the human one, does not perform a chemical speciation of the analyzed odor and is not able to identify the individual molecules that compose it, but the set of sensors produces a sort of "olfactory fingerprint", which can be classified based on a reference database acquired by the instrument in a preliminary training phase. Its operation is fundamentally based on a set of sensors (arrays), whose characteristics vary according to the models and substances to be detected (sniff), and a pattern recognition system. This instrument uses the electrical conductivity variations of the sensors, induced by the volatile organic components of the compounds (VOCs), and translates them into signals processed using an appropriate software. The reaction mechanism is based on an exchange of oxygen between the volatile molecules and the metal film, which causes a change in resistance recorded and correlated to the adsorbed compounds.

Cheese samples were analyzed using a 10-MOS electronic device (PEN-3, Airsense Analytics GmbH, Schwerin, Germany) equipped with ten MOS-type sensors (Table 4).

Tab. 4 Features of the PEN3 electronic nose sensor array

N. in Array	Sensor	Name Reaction	Compound Typical Target
S1	W1C	Aromatic compounds	C6H5CH3
S2	W5S	Oxynitride	NO2
S3	W3C	Aromatic constituents, mainly ammonia	C6H6

S4	W6S	Hydrogen	H2
S5	W5C	Alkanes, aromatic compounds	C3H8
S6	W1S	Broad Methane	CH4
S7	W1W	Sulphides and organic sulphides	H2S
S8	W2S	Broad alcohols	C2H5OH
S9	W2W	Aromatics, organic sulphides	H2S
S10	W3S	Alkanes, especially methane	CH4

For each experimental cheese thesis (Grappa, Marsala and Control), 4 samples were used. Each sample was divided into 6 replicates (a,b,c,d,e,f), weighing about 2 grams. The cheese samples were placed in 45 ml vials, kept in a water bath at a temperature of 25°C, for the time necessary to saturate the head space of the vial. Each run lasted 300 sec, but the actual detection was limited to the last 60 sec, the initial phase of the run is used to clean the sensors and stabilize the baseline. Typically the last 10 sec of the run are processed, which represent the stabilized phase of the detection curve. The 10 MOS sensors simultaneously collect 10 data sets (variables) in a measurement run, which together represent the numerical version of the volatile component accumulated in the headspace of the vial containing the sample. Each measurement, was controlled and recorded in a text file by using WinMunster v.1.6.2.2 software (Airsense Analytics GmbH).

Fig. 37– Goat cheese sampling for electronic nose analysis (Grappa, Marsala and Control cheese).

Fig. 38– Goat cheese sampling for electronic nose analysis (Grappa, Marsala and Control cheese).

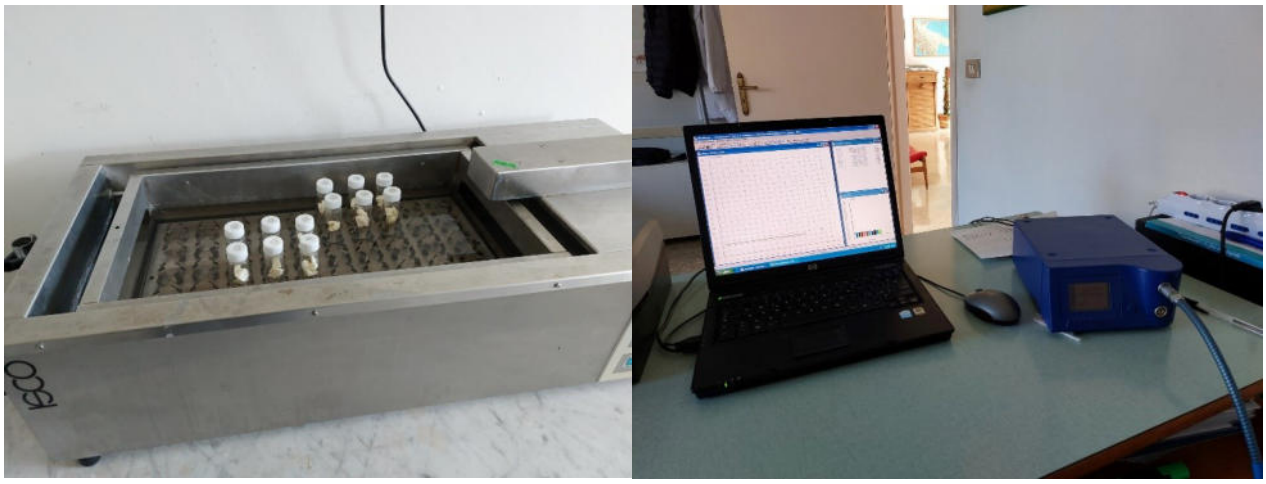

Fig. 39 – Electronic nose analysis for goat cheese.

The pattern recognition system made it possible to acquire data during the analysis and subsequently process it.

Statistical Analysis

Multivariate statistical methods principal component analysis (PCA) and linear discriminant analysis (LDA) were used for classification, and partial least squares (PLS) regression were used for the recognition of an unknown sample, which gave adequate results, as it inserted each "unknown" sample into its own class of belonging.

7. RESULTS AND DISCUSSIONS

The gross composition of cheese at the end of ripening is shown in Table 5. The chemical composition of cheeses refined in a mixture of hazelnut perisperm and grappa or marsala showed no significant differences.

Tab. 5 Chemical composition of cheeses refined in a mixture of hazelnut perisperm and grappa or marsala (A and B)

Treatment	DM	Protein	Fat	Ash	Polynsatured
A	54,40	41,87	52,19	13,16	0,84
B	54,59	41,85	52,23	13,13	0,89

Sample A: goat's cheese with the addition of a mixture of hazelnut perisperm and grappa; Sample B: goat's cheese with the addition of a mixture of hazelnut perisperm and marsala

The general opinion expressed by the recruited consumers was particularly interesting in highlighting that the addition of perisperm did not confer any additional aromatic attributes to the cheese, even if they preferred the grappa variant.

Acceptance of goats' cheeses aged in a mixture of hazelnut perisperm and grappa (A) and marsala (B) (mean±DS) is shown in the table below.

Treatment	Sensory parameter				
	Color	Odor	Flavor	Texture	Overall liking
A	7.08±1.00	7.25±1.20	7.00±1.60	7.16±1.51	7.51^{a}±1.42
B	7.06±1.06	7.32±1.24	7.01±1.33	7.04±1.45	7.09^{b}±1.25

$^{a, b} = P < 0.05$.

Tab. 4 Acceptance trial

- A, goats aged in a mixture of hazelnut perisperm and grappa;
- B, goats aged in a mixture of hazelnut perisperm and Marsala

Particularly, at 30 days of ripening, the cheese ripened in a mixture of hazelnut perisperm and grappa scored above 7 ($P < 0.05$) for overall judgement (7.51 vs 7.09).

The results, relating to the data processing of the "electronic nose", showed, through the multivariate analysis, a significant effect of the different theses compared.

Headspace analysis of cheese was performed using an electronic nose with 10 sensors. The built-in soft-ware of the electronic nose was able to clearly separate the thesys. A PCA was performed on the correlation matrix of sensor responses and the results are shown in Figure 40.

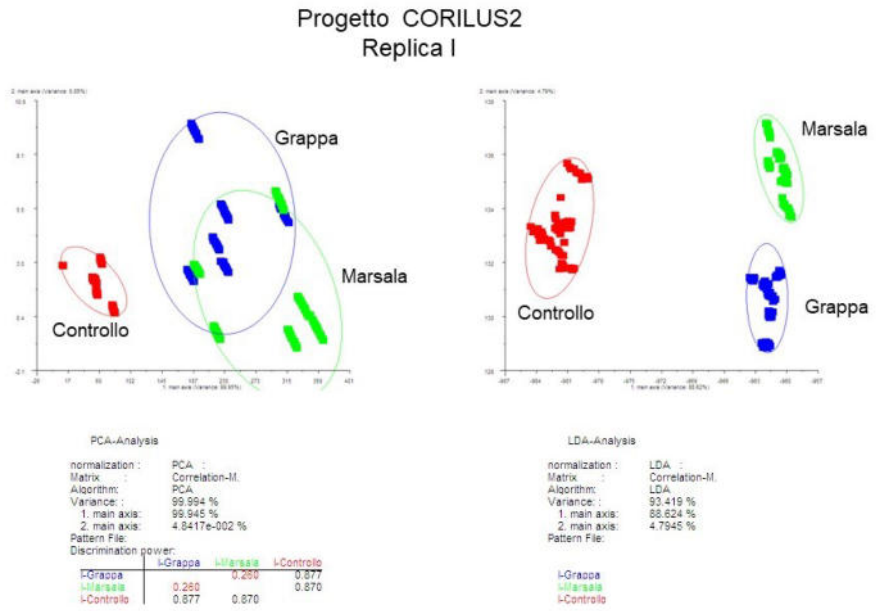

Fig. 40 – Electronic nose analysis for goat cheeses

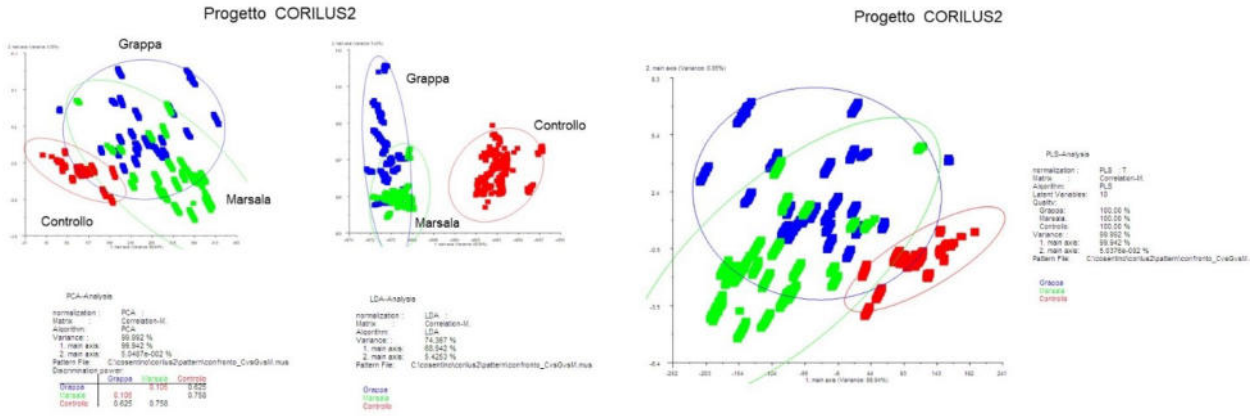

Fig. 41 – Electronic nose analysis for goat cheeses

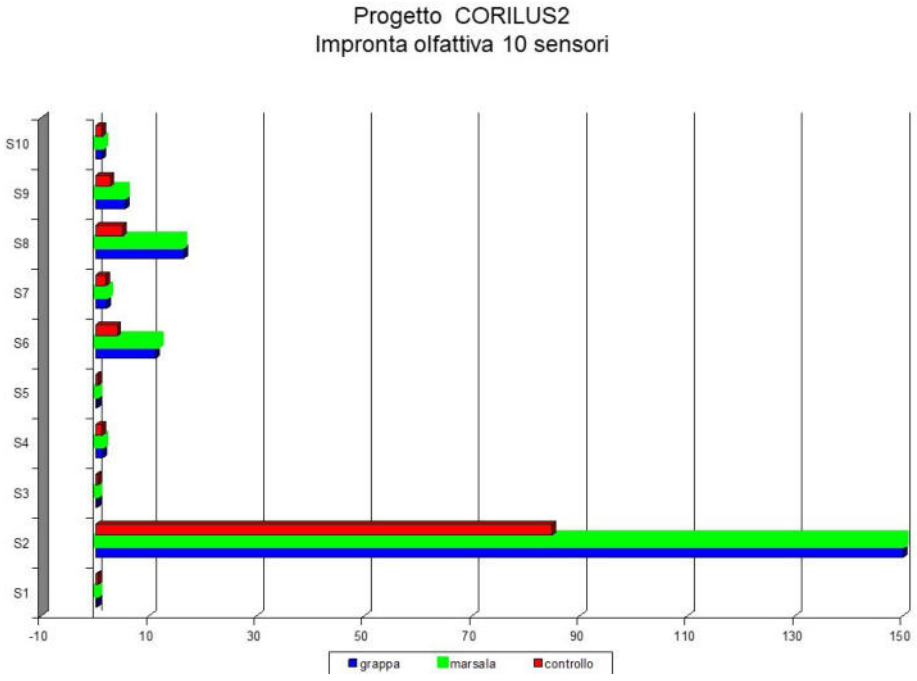

Fig. 42 – Electronic nose analysis for goat cheeses

A PLS-discriminant analysis was also used to evaluate the effect of theses. Although electronic noses lack selectivity, they are a fast and relatively inexpensive tool to assess cheese aroma, compared with GC-MS.

Because of their multivariate nature, electronic nose data are treated by multivariate statistical methods, including PCA, discriminant analysis, and artificial neural networks, and the purpose is often discrimination of groups rather than inference on the effect of design variables. Although it is difficult to compare our data with those of other studies because of differences in the set-up and type of sensors, we confirmed that addition of adjuncts significantly affects the aroma of a cheese even over short ripening times.

In conclusion, the cheeses with a mixture of hazelnut perisperm and marsala preference in combination with specific communication, marketing and packaging operations might be sufficient to successfully propose this new product in a food market that is increasingly focused on nutraceutical and innovative products.

There are few studies available in the literature on the acceptability of fresh goat cheeses. Such cheeses vary widely depending on the type of milk used, whole goat or mixed with sheep, the cheesemaking process, ripening time and type of feed. Morand-Fehr et al. (2007) reported that pasture positively influences the identification of typical flavours in milk and cheese of small dairy ruminants. Morsy et al. (2015) reported that dietary supplementation containing sunflower or sunflower oil did not influence the sensory parameters of goat cheeses.

There are no studies using perisperm for cheese refinement. Caccamo et al. (2019) evaluated the addition of perisperm to the feed of dairy sheep, and obtained significant results on the cheeses produced in terms of sensory analysis and fatty acid content.

The use of hazelnut perisperm for refinement in grappa and marsala reported no significant differences for the various parameters.

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