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CICLO XXII

ORGANIC ANIMAL PRODUCTION SYSTEMS AND QUALITY OF PRODUCTS FROM RUMINANTS

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RIASSUNTO

Questa attività di ricerca ha avuto come obiettivo quello di investigare la qualità del latte bovino e caprino, di formaggi e di carne di vitello ottenuto da allevamenti biologici in zona montana. Sono state impostate quattro prove sperimentali che hanno valutato le caratteristiche chimiche, tecnologiche e nutrizionali di prodotti ottenuti da allevamenti biologici e convenzionali localizzati nella Regione Veneto.

Il primo studio sulla qualità del latte ottenuto da allevamenti biologici e convenzionali di vacche da latte in zona montana ha evidenziato una sostanziale similitudine nella composizione chimica e nelle caratteristiche tecnologiche del latte ottenuto con i due diversi sistemi di produzione. Il profilo acidico del grasso del latte, invece, è risultato più favorevole dal punto di vista nutrizionale nel latte ottenuto da allevamenti biologici.

Nel secondo studio sui formaggi ottenuti con latte biologico e convenzionale sono state confermate le differenze relative al profilo acidico, risultato ancora una volta più favorevole nei formaggi biologici. E' stato possibile utilizzare alcuni parametri del profilo acidico per poter discriminare formaggi ottenuti con sistemi di produzione diversi e in mesi diversi. In particolare la quantità di acidi grassi polinsaturi, il contenuto di acidi grassi della serie n3 e i CLA, sono risultati più elevati nei formaggi estivi di produzione biologica. L'elevato contenuto di α-tocoferolo rilevato nel formaggio biologico ha portato a una colorazione brillante e più gialla rispetto ai formaggi convenzionali. Dall'analisi sensoriale non sono emerse particolari caratteristiche del formaggio ottenuto con latte biologico che quindi non è possibile discriminare rispetto ai convenzionali con prove di degustazione.

Nel terzo studio, l'indagine riguardante le aziende biologiche di capre da latte presenti nella Regione Veneto, ha evidenziato una grande variabilità nella gestione alimentare delle aziende. Il lavoro ha rilevato concentrazioni elevate di CLA nelle aziende che hanno effettuato pascolo per tutti i mesi estivi.

Nel quarto studio la carne di vitello ottenuta con metodo biologico è risultata più magra e con un più basso contenuto di colesterolo rispetto alla carne di vitello convenzionale. Il quantitativo di ferro eminico nella carne biologica è risultato quasi il doppio rispetto alla carne convenzionale causando una colorazione più rossa della carne biologica. Questo aspetto può penalizzare la commerciabilità del prodotto in quanto una colorazione rossa della carne di vitello non è apprezzata dal consumatore che desidera una carne rosata (carne "bianca").

Nel complesso questa attività di ricerca ha permesso di affermare che la zootecnia biologica in montagna si può proporre come metodo per la valorizzazione di alcune produzioni e la sostenibilità degli allevamenti.

SUMMARY

This research activity aimed at investigating cow and goat milk and cheese quality, organic beef quality in mountain areas. Experimental trials were set-up to evaluate the chemical, technological, and nutritional characteristics of products obtained in organic and conventional farms located in the Veneto region. From the first study on the quality of milk from organic and conventional farms in mountain areas the milk was found to be substantially similar for chemical composition and technological properties despite two production systems were used. The fatty acid profile, instead was viewed favorably from a nutritional point of view for milk obtained form organic farming. Based on the trial carried out on cheese made from organic and conventional milk the differences in fatty acid profiles were confirmed, once again in favor of organic cheeses. It is possible to use some of the fatty acid profile parameters (saturated, mono-unsaturated, poly-unsaturated fatty acids, and ratio for some fatty acids of nutritional interest), to distinguish cheese based on the production system used and period of production. Special interest is paid for poly-unsaturated fatty acids, n3 and CLA fatty acids, which are found in cheeses produced in summer from organic milk. Organic cheese is more yellow and brighter in colour than conventional cheese because it is richer in α-tocopherols. From the sensory analysis no distinctive characteristics resulted for organic cheeses, so it is not possible to distinguish them from conventional ones through taste trials. In the third study, the investigation carried out on organic dairy goat farms in the Veneto region has shown great variability in feed management in farms. Regarding the fatty acid profile for goat milk, the study has revealed better results when grazing was possible; particularly high concentrations of CLA were found in farms where grazing was allowed in the summertime. In the fourth study, organic calf farming results in leaner animals, with lower cholesterol content, compared to conventionally farmed calves. The quantity of haeminic iron in organic meat almost doubles that found in conventional meat, which causes organic meat to be darker. This aspect is viewed negatively form a commercial point of view: darker meat is not appreciated by consumers who expect it to be slightly pink in colour (“white meat”).

Overall, with this thesis it was possible to affirm that organic-farming mountain livestock could be exemplified as the method to use for increase the value of productions and sustainable farming.

CHAPTER 1

Introduction

The first section of this introduction chapter reported a present situation about the new EU regulation in force. Subsequently a review about the studies on the effect of organic production systems on milk and meat quality is reported.

1.1 EU REGULATION OF ORGANIC PRODUCTIONS

On 1 January 2009 the new Commission Regulation (EC) 834/07 that review in structural way the European rule in matter of organic productions became effective. Following that the dated Council Regulation (EEC) No 2092/91, which we must recognize as the most important role of organic production increase in these years, was totally repealed. Other than revise the rules of production, labelling and the control system till now applied, the new regulation extends the field of application to the interesting new certification categories of products: aquaculture, wine, seaweed and yeasts.

The following regulations of implementation No 899, published on 17 September 2008, detail the technical norms and the criteria of control for the agricultural production, the animal production and the feeding preparation.

Another rule of implementation, No 1235, published on 8 December 2008, establish the modalities of application of regulations EC No 834/07 regarding the regime of import of organic products from third countries. Others two regulations (Reg. EC No 967/08 and No 1254/08) have already modified the applicative dispositions, postpone to 1 July 2010 the obligation of employment of community logo for the products obtained in the member states and specify the rules for the production of organic yeast.

Regards laying down detailed rules on organic aquaculture animal and seaweed production a Commission Regulation (EC) No 710/09 was published on 5 August 2009.

It is necessary instead waiting for the rule about organic wine.

In Italy the ministerial regulation, expected within February 2009, was finally published in November. This regulation, No 18354 published on 27 November 2009, revise the outdated enforcement rule (No 220/95) and follows ministerial decree dated 4 August 2000, 29 March 2001 and 7 July 2005 about animal production.

The following table (Table 1.1) summarizes the new rule in matter of organic production with a briefly description of contents.

Table 1.1 List of new regulations about organic production

EU rule in force	Reg. EC 834/07	On organic production and labelling of organic products and repealing Reg. (EEC) No 2092/91. Application field, general production rules about organic system, control system, labelling, regime of import of organic products from the third countries
Detail rules for implementation of Reg. EC 834/07 on specific topics	Reg. EC 889/08	Detailed rules on organic production and labelling of organic products. It specifies about labelling and use of community logo and control system.
	Reg. EC 967/08	Postpone to 1st July 2010 the obligation about use of community logo
	Reg. EC 1235/08	Detailed rules as regards the arrangements for imports of organic products from third countries
	Reg. EC 1254/08	Exceptional production rule with regard to the use of specific products and substance in the processing (Admitted until 2013)
	Reg. EC 710/09	Detailed rules as regards laying down detailed rules on organic aquaculture animal and seaweed production
Italian regulation	Italian MD 18354 published on 27/11/09	Disposizioni per l'attuazione dei regolamenti (CE) n. 834/2007, n. 889/2008, n. 1235/2008 e successive modifiche riguardanti la produzione biologica e l'etichettatura dei prodotti biologici.

The first important news is the extension of the application field in the regulations No 834/07 to organic aquaculture, wine, seaweed and yeasts.

The use of genetically modified organisms (GMOs) remains banned. The general limit of 0.9 percent for the accidental presence of authorized GMOs is also applied to organic products. There are no changes in the list of authorized substances for organic farming.

The use of the EU organic logo will be obligatory, but it can be accompanied by national or private logos. Italy has expressed the purpose to create a brand that identifies the Italian organic products for the protection and promotion of the national productions. For long years the Reg. EEC 2092/91 has forbidden to link the organic term to the name of the product, but only to the method of production, in fact in Italy was used “Produced from

Organic Agriculture". The new regulations, instead, allow also the use of the claim "Organic Products", much more appreciated by marketing people and abroad, in particular in the markets of the North Europe.

Food will be able to carry an organic logo if at least 95 percent of the ingredients are organic. However, remaining 5% of non-organic products must be a part of list of conventional admitted ingredients.

Commission EU start up to proceed to the graphical review of the European logo. The current version of EU logo, very common in the Italian organic products, it is not appreciated in the countries of the North Europe because of the insufficient immediacy of the message and a graphical form that gets confused with the typical products. A graphical suggestion of new EU logo, already submitted to the evaluation of member states, has demonstrated too much similarity to the image adopted from an important German distributive chain (ALDI) for the private organic products label. Because of the withdrawal of the new one logo for the organic products, commission EU has decided to postpone to July 2010 the date after which the logo will be mandatory.

As regard control system is confirmed the possibility for the member states to choose among a private control systems, exclusively to private control organisms opportunely authorized (e.g. Italy and the most of the other countries members), a control system exclusively to public authorities of control (e.g. Denmark), or a mixed system (e.g. Spain, Great Britain).

In Italy the recent ministerial decree, No 18354 published on 27 November 2009, has permitted the homogeneous enforcement on the national territory of the European regulations No 834/2007 and relative implementation rules. This rule is important for Regions and Provinces especially for the necessity of some dispensations decay since the introduction of new European rules. This decree also give some clarification about several expressions to avoid a possible loose interpretation of community regulations.

A "major extension to the farm" (paragraph 4 of the art.9 of the Reg. EC 889/2009) means an increase of at least 20% of adult bovine and 30% of other categories but is not included the cooperation agreements.

For "common grazing area" (paragraph 3 of the art.17 of the Reg. EC 889/2009) areas of Public Authority, area with civic use of pasture or area indicated in No 1766 law published on 16 June 1927 are intended. No additional clarification is reported about the modality of access to open air areas (art. 14). Follow this all categories of herbivores shall have access to pasturage for grazing whenever conditions allow and is not anymore possible to give access to pasture only for a limited category of animal (e.g. dry cows).

Other information included in ministerial decree regards art.15 about stocking density. The competent authority which set out the livestock unit equivalent to the limit of 170 kg of nitrogen per year and hectare of agricultural area is the appropriate Region or Province on the territory.

About exceptional production rules and in particular about tethering of animals (art. 39) an important explanation is reported in the decree. The competent authorities may authorise cattle in small holdings to be tethered. “Small holdings” meaning the farms with an average annual consistency not over 30 Bovine Adult Unit.

1.2 EFFECT OF ORGANIC PRODUCTION SYSTEMS ON MILK QUALITY

Several comparative studies focus on the quality of milk from conventional and organic production. These studies are different in term of type of study (survey or experiments), location (country, region, marginal area), farms or animals used and so on. For this it is difficult to put together these researches also because of the different organic management and reality present in each country that should be produce different effect on milk quality. However a review of these studies was reported separated in subchapters according to the milk compound studied.

1.2.1 Protein content in organic and conventional milk

The factors that affect protein composition in bovine milk are manifold (Coulon et al., 1998; Mackle et al., 1999) and can be summarized as follows: genetic characteristics of animals, type of management, udder condition, nutritional factors, animal health, milking intervals and stage of lactation. Probably the breed and the individual selection of the animals were the most effective way to control the proper protein composition for cheese and dairy products manufacturing (Malossini et al., 1996; Chiofalo et al., 2000; Auldist et al., 2003).

Regarding to the protein content in organic milk, Toledo et al. (2002) was found no difference in protein composition in comparison with milk from conventional farms. Instead, other studies showed lower milk protein concentrations in organic milk (Jahreis et al., 1996; Olivo et al.,2005; Butler et al.,2008) while other studies report an higher percentage of milk protein, or in specific casein content, in organic milk respect to the conventional one (Bakutis et al., 2007; Anacker et al.,2007). Organic production also affects nitrogen composition of milk. The results of Toledo-Alonzo (2003) suggest that organic dairy systems produce milk with lower urea concentrations compared with conventional farms of the same size, explained the lower production intensity and percentage of concentrates in animal diet in organic systems (Table 1.2).

Table 1.2. Summary table of comparative studies from literature of protein, casein and urea content in organic (ORG) and conventional (CON) milk.

Parameter	*ORG vs CON*	*Authors (Country)*
Protein	ORG=CON	Toledo et al., 2002 (Sweden)
	ORG<CON	Jahreis et al., 1996 (Germany); Olivo et al., 2005 (Brazil); Butler et al., 2008(Denmark)
	ORG >CON	Lund, 1991 (Belgium); Bakutis et al., 2007 (Lithuania)
Casein	ORG>CON	Lund et al., 1991 (Belgium); Anacker, 2007 (Germany)
Urea	ORG<CON	Toledo-Alonzo, 2003 (Sweden)

1.2.2 Hygienic-sanitary parameters and animal health in organic and conventional milk

About hygienic-sanitary parameters the studies in literature are opposing. Many authors (Hauert et al., 1990; Lund, 1991; Hardeng et al., 2001; Boutet et al.,2005; Bakutis et al., 2007; Valle et al., 2007; Fall et al., 2008) found no difference regarding both somatic cell count and bacterial count. Other researches (Toledo et al., 2002; Bennedsgaard et al., 2003; Hamilton et al., 2006; Ellis et al., 2007) reported a lower content of somatic cell count in milk obtained from organic farms. On the contrary, other authors (Hovi et al., 2003; Busato et al., 2000; Nauta et al., 2006) found a higher content both bacterial count and somatic cell count in comparison with conventional milk (Table 1.3). Many of these trial studies also the incidence of mastitis in the organic farmer considering that milk from cows infected with mastitis generally have higher total bacteria counts and somatic cell counts than milk from uninfected cows. Ellis et al (2007) found a lower mean monthly lactating cow clinical mastitis incident on organic farming compared with conventional farm (3.5 vs 5.6 cases/100 cows in milk/month). The Norwegian study (Hardeng et al., 2001), reported better health performance (mastitis, ketosis and milk fever) for organic than for conventional dairy herds while Busato et al. (2000) showed a high prevalence of subclinical mastitis in organically managed Swiss dairy herds.

Some local or national conditions like traditions for management, use of medication or herd size could explain differences between the results.

Studies of health on organic dairy farms are few and those that have compared health performance in conventional and organic farms have given conflicting results (Hovi et al., 2003). In a literature review, Lund et al. (2003) concluded that 'health and welfare in organic herds are the same as or better in conventional herds'.

Table 1.3. Summary table of comparative studies from literature of hygienic-sanitary parameters (somatic cell count, SCS, and total bacterial count, TBC) in organic (ORG) and conventional (CON) milk.

Parameter	*ORG vs CON*	*Authors (Country)*
SCS and TBC	No differences	Hauert et al., 1990 (Germany);Lund, 1991(Belgium);Hardeng et al., 2001 (Canada); Boutet et al.,2005 (Belgium); Bakutis et al., 2007(Lithuania); Valle et al., 2007 (Norway); Fall et al., 2008 (Sweden)
SCS	ORG>CON	Hovi et al., 2003 (Denmark); Busato et al., 2000 (Switzerland); Nauta et al., 2006 (The Netherlands)
	ORG<CON	Toledo et al., 2002 (Sweden); Bennedsgaard et al., 2003 (Denmark); Hamilton et al., 2006 (Sweden); Ellis et al., 2007 (UK)

1.2.3 Fatty acids profile in organic and conventional milk

Fat is the milk component that varies most and the percentage of fatty acids that comes from the animal's diet can above to 50% (German et al., 2006). Milk fat has a great variance in fatty acids composition depending on the nutrition, genetics, health of the animal and management of the farm. These alterations are stronger for fat than for protein or carbohydrates in milk (Hawke et al., 1995). The changes in milk fat composition influence physical and nutritional proprieties of milk (Wijesundera et al., 2003) and they can be easily reached through the control of farm management (Stockdale et al., 2003). Animal diet is the factor that can mainly influence fatty acids composition of milk (Chilliard et al., 2000). Many researches investigate the modification of milk fat composition. Nutritional manipulation of the dairy cows is the most proper strategy for improving fatty acids composition in milk (Avramis et al., 2003).

Approaches that are linked to animal nutrition should focus on decrease of saturated fatty acids (SFA) and increase of polyunsaturated fatty acids (PUFA), so the consumption of milk can reflect an improvement of human health (Shingfield et al., 2005).

In particular n-3 and n-6 fatty acids have shown significant effects of human health. Effects of n-3 fatty acids on human body have been investigated by many authors and which were summarized to: neurological function (Cuntreras et al., 2002), protection against coronary heart disease (Williams, 2000; Butcher et al., 2002; Hu et al., 2002), decrease of cardiovascular disease (Hu et al., 2002), prevention of cancer (Parodi et al., 1999; Saadatian-Elahi et al., 2004), antiatherogenic and antiobesity function (Whigham et al., 2000). About n-6 fatty acid (among which linolenic, γ-linolenic and arachidonic acid) pro-inflammatory effects and anti-inflammatory proprieties for fatty acids derive from eicopentaenoic acid (EPA) were studied (Tapiero et al., 2002). Some opposite effects of the two groups of fatty acids makes necessary estimate the n6:n3 ratio (Tapiero et al., 2002). Low ratio of n6:n3 has been linked with the action against the breast cancer and metastasis (Cowing et al., 2001). Simopoulos (2002) suggested that a recommended ratio of n6:n3 FA in human nutrition variable from 1:4 to 1:1, depending on the specific needs and condition of the individual. FAO/WHO (1994) suggested an n6/n3 ratio with a range from 5:1 to 10:1 while Western diets are deficient in n3 FA and have an excessive amount of n6 and the ratio is 15:1-16.7:1.

Among unsaturated fatty acids, conjugated linolenic fatty acids (CLA) have attracted the attentions of researchers for the beneficial effects of its consumption in human diet (Chin et al., 1992). CLA is a group of geometric and positional isomers of linolenic acids (Whigham et al., 2000). The isomer of cis-9 trans-11 C18:2 are the predominant isomers of CLA in milk, at 75-90% of the total isomers of CLA. CLA is endogenous produced in cows and humans. There are two ways through which CLA is produced: the hydrogenation of dietary linolenic acid in the rumen by microorganisms or the endogenous synthesis in the mammary gland and adipose tissues, using vaccenic acid as a precursor (Bauman et al., 2003). The second way contributes for about 80% of the total CLA in milk (Bu et al., 2007).

The beneficial effects of CLA in human health have been extensively studied. It inhibits cancer growth, reduces plasma cholesterol, improves hyperinsulinemia and modulates lipid metabolism (Belury, 2002; Nagao et al., 2005; German et al., 2006). Milk CLA content is high compared with other foods, ruminant meat is also a good source of CLA (Chin et al., 1992). Both ruminant milk and meat are major contributors of CLA intake in human diet (Parodi et al., 1999). The CLA concentration in milk fat is affected by animal diets and can vary over fivefold (Bauman et al., 2003). Grazing pasture (Dhiman et al., 1999; Ellis et al., 2006), oil supplementation (Kelly et al., 1998), control of forage:concentrate ratio (Jiang et al., 1996) and silage type (Ellis et al., 2006) can improve milk CLA content.

Organic systems are dependent on grass and forages. Many authors compared the FA profile of organic milk to that of conventional milk (Toledo et al., 2002; Bergamo et al, 2003; Ellis et al., 2006; Molkentin et al, 2007; Lavrenčič et al., 2007; Anacker et al., 2007; Collomb et al., 2008; Table 1.4). Other authors compared the FA profile between organic and conventional milk with from other pasture-based systems (Jahreis et al., 1997; Croissant et al., 2007; Butler et al., 2008; Slots et al., 2009). All authors found a lower SFA concentration and a higher PUFA concentration in organic milk compared with conventional milk; only a study of Butler et al. (2008) reported no significant difference in PUFA concentrations between organic and conventional milk. The role of pasture intake on the milk FA profile was widely discuss in many scientific articles (Dhiman et al., 1999; White et al., 2001; Stockdale et al., 2003; Croissant et al., 2008). Milk from pasture-based system has linked with lower content of SFA and higher content of unsaturated fatty acids than conventional milk (Jahreis et al., 1997; Slots et al., 2009). Also higher concentration of vaccenic acid and CLA was found in organic or pasture-based milk (Dhiman et al., 1999; White et al., 2001; Stockdale et al., 2003; Bergamo et al., 2003; Croissant et al., 2007; Collomb et al., 2008; Butler et al., 2008) while a few studies reported no effect of organic or pasture-based diet in the content of CLA in milk (Ellis et al., 2006; Bargo et al., 2006; Slots et al., 2009). Lower n-6: n-3 ratio was also found in organic milk respect to the conventional one in recent studies (Ellis et al., 2006; Collomb et al., 2008; Slots et al., 2009). A study of Thorsdottir et al., (2004) reported a ratio of 1:4.7 in conventional milk from Nordic countries, while milk from Iceland has a value of 1:2.1. Ellis at al. (2006) propose that the research on organic milk production should be carried out in each country independently because of the different organic management in each area that should be produce different effect on milk quality.

Cows fed with pasture and housed outdoor compared with the cows fed with concentrates-diet and housed indoor, produce milk with less myristic and palmitic FA due to the higher intake of unsaturated FA in the pasture (Agenas et al., 2002). Total Mixed Ration (TMR) seems to raise milk content of C4-C16 FA in the seasons that SFA is usually low, as spring and summer (Ellis et al., 2006). A study of Agenas et al. (2002) investigates the changes on milk composition from the introduction of pasture in the cow’s diet. From the 1^{st} to the 8^{th} day from the start of grazing, the milk content of linolenic, α-linolenic and oleic acid were elevated and the oleic acid as well as vaccenic acid and CLA increase until the 29^{th} day.

Table 1.4. Summary table of comparative studies from literature of fatty acid profile in organic (ORG) and conventional (CON) milk

Parameter	*ORG vs CON*	*Authors (Country)*
Saturated FA Unsaturated FA	ORG<CON ORG>CON	Toledo et al., 2002 (Sweden); Bergamo et al, 2003 (Italy); Ellis et al., 2006 (UK); Molkentin et al, 2007(Germany); Lavrenčič et al., 2007 (Slovenia); Anacker et al., 2007 (Germany); Collomb et al., 2008 (Switzerland)
Polyunsaturated FA	No differences	Butler et al., 2008 (UK)
Conjugated linolenic acid	No differences BIO > CON	Ellis et al., 2006 (UK); Nielsen et al., 2004 (Denmark) ; Bargo et al., 2006 (Netherlands); Lavrenčič et al., 2007 (Slovenia); Slots et al., 2009(UK) Bergamo et al., 2003 (Italy); Croissant et al., 2007 (USA); Molkentin et al., 2007 (Germany)

1.2.4 Vitamins and minerals content in organic and conventional milk

Natural antioxidants included in milk, α-tocopherol and β-carotene can be transferred from the cow's diet to the milk and give the product with required antioxidative capacity (Barrefors et al., 1995; Jensen et al., 1999; Havemose et al., 2004). Positive correlation was found between the concentration of β-carotene and vitamin A in milk and the content of β-carotene and vitamin A in forages (Havemose et al., 2004; Noziere et al., 2006). Organic systems and grazing intake increase the content of these antioxidants in milk (Jensen et al., 1999; Lindmark et al., 2003; Bergamo et al., 2003; Slots et al., 2009). In an investigation of the vitamins content in milk from UK organic and conventional farms, Ellis et al. (2007) report no significant differences in the vitamin E or β-carotene contents between the two types of milk and conventionally produced milk fat had higher vitamin A content, possible due to increased vitamin A supplementation in concentration feeds. In a study about the content of vitamins in organic and conventional milk from Danish dairy plant, Nielsen et al.

(2004) reported higher content of vitamin E in organic milk than in conventional milk and β-carotene resulted 2 to 3 times higher in organic milk than in conventional milk. About the role of these vitamins on human health Haugh et al. (2007) have reported that milk vitamin E, which in milk consist of >85% α-tocopherol, shows anticancer proprieties, improve immune system and protect against coronary heart disease.

About mineral content Toledo et al. (2002) found a lower content of selenium in organic milk in comparison with Se content in conventional Swedish milk. In addition, the authors showed a lowest content in milk obtained during grazing period, explained with the low content of selenium in the soil of Sweden. A study of Hermansen et al. (2005) about major and trace elements in organic and conventional milk show a higher concentration of molybdenum and a lower concentration of barium, europium, manganese and zinc in organically produced milk respect to conventional milk. (Table 1.5.).

Table 1.5. Summary table of comparative studies from literature of vitamins and minerals content in organic (ORG) and conventional (CON) milk.

Parameter	*ORG vs CON*	*Authors (Country)*
Vitamin A (β-carotene)	ORG<CON ORG>CON	Ellis et al., 2007 (UK) Bergamo et al., 2003 (Italy); Nielsen et al., 2004 (Denmark); Slots et al., 2009(UK)
Vitamin E (α-tocoferolo)	ORG>CON	Bergamo et al., 2003 (Italy); Nielsen et al., 2004 (Danish); Slots et al., 2009 (UK)
Selenium	ORG<CON	Toledo et al., 2002 (Sweden)
Other minerals	Mo > ORG Mn, Zn < ORG	Hermansen et al., 2005 (Denmark)

1.2.5 Chemical safety in organic and conventional milk

The presence of organochlorinated pesticides, PCBs, heavy metals and aflatoxin M1 has been evaluated in organic and conventional milk by many authors. All studies in literature reported the absence or a quantity above law limits of these compounds in milk or dairy products come from certificated organic farms (Lund et al., 1991; Anacker et al., 2007; Knoppler et al., 1986; Skaug, 1999; Vallone et al., 2006).

1.3 EFFECT OF ORGANIC PRODUCTION SYSTEMS ON MEAT QUALITY

In 2003, EU, including 15 countries, certified about 1 million of non-dairy cattle, corresponding to 1.7% of total non-dairy cattle herd (European Commision, 2005). Austria ranked first with 25% of EU followed by Italy with 15%. Beef had the highest market share (1.7%) followed by sheep and goat meat (0.7%), pork (0.3%) and poultry (0.3%) (Hamm et al., 2002). However mainly researches were focused on non ruminant meat quality, with pigs and broilers species involved.

Organic rules clearly affect farming practices, which can influence meat quality (Braghieri et al., 2009). In many studies, the overall production system was considered; in others the effects of single factors aspects covered by the organic standards (such as grazing and forage based diet) were evaluated. (Table 1.6)

Table 1.6. Summary table of comparative studies from literature of effect of single aspect covered by the organic standards on meat quality characteristics (modified by Braghieri et al., 2009)

Property	*Outdoor/Grazing/Forage based diet*[1]	*Authors*
Intramuscular fat content	-	Vestergaard et al., 2000
Warner Bratzler Force	-	Vestergaard et al., 2000
Tenderness	+/- + -	French et al., 2000; French et al., 2001 Oltjen et al., 1971 Bennet et al., 1995
Taste	-	Vestergaard et al., 2000
Colour (yellowness and redness index)	+	Vestergaard et al., 2000;Yang et al., 2002; Olivan et al., 2009
PUFA/CLA	+	French et al., 2000; Yang et al., 2002; Realini et al., 2004; Nielsen et al., 2005; Marino et al., 2006
Oxidative stability	+	Descalzo et al., 2005; Descalzo et al., 2007; Olivan et al., 2009

[1]+:increase;-:decrease:+/-:no effect.

The organic production system may result in a decrease of the technological characteristics of cattle meat. The promotion of the use of pasture and outdoors area increases the physical exercise of animals and this latter negatively affect beef, with higher shear values, reduction of taste and darker meat colour (Vestergaard et al., 2000). Nuernberg et al. (2005) also observed that bulls fed on grass, include pasture, showed a colour of muscle darker than concentrate-fed animals. These results are generally due to the increase activity of grazing animals (Priolo et al., 2001; Millet et al., 2004) mainly due to high levels of myoglobin in the muscle (Shorthose et al., 1991). Ranucci et al. (2005) found no differences in physical proprieties on organic beef compared with meat obtained with the PGI-system. About the effect of forage inclusion on tenderness, the results in literature are controversial. Some studies found no difference in tenderness between grain and forage-diet beef (French et al., 2000; French et al., 2001), other researches indicate an increase of tenderness in forage-fed cattle (Oltjen et al., 1971) or in grain-fed cattle (Bennet et al., 1995). However, differences in tenderness between organic and conventional meat were not detected by a descriptive sensory panel, nor by a consumer preference test, that did not allow to discriminate organic from conventional meat (Olsson et al., 2003; Millet et al., 2005). These results suggest that other factors, such as genetics or slaughter age interfere with the tenderness of final product. Grazing and high space available were also related to the high energy expenditure and low fatness (Enfant et al., 1997, Sather et al., 1997). High levels of forage intake, including grass from pasture, in organic animals can determine changes in the fatty acids profile of intramuscular fat, with higher content of unsaturated fatty acids. Nielsen et al. (2005) observed a higher ratio of unsaturated to saturated fatty acids on organic beef cattle subjected to pasture-based diet. Similar results were found in Podolian young bulls fed with high forage to concentrate ratio (Marino et al., 2006). Many researches reported an higher content of conjugated linolenic acid (CLA) in meat from cattle fed large amount of forage or fed on pasture (French et al., 2000; Yang et al., 2002; Realini et al., 2004; Nielsen et al., 2005) with well-know beneficial effect on human health (Pariza et al., 2001). In addition beef produced on pasture have higher oxidative stability than meat from conventional animals (Descalzo et al., 2005; Descalzo et al., 2007; Olivan et al., 2009) due to the protection conferred by natural antioxidant present in grass. Pasture intake confers high levels of vitamin E, β-carotene and vitamin C (Yang et al., 2002; Descalzo et al., 2005). The high level of β-carotene intake produce a yellow fat, so pasture-based diet meat results with higher yellowness index respect to meat from grain-fed animals (Yang et al., 2002; Olivan et al., 2009).

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CHAPTER 2

Chemical, nutritional and technological characteristics of milk obtained from organic and conventional dairy farms located in the mountain area

Study results presented at EAAP – 58th Annual Meeting,

Dublin, Ireland. 26-29 August 2007

2.1 INTRODUCTION

Among organic animal production, milk and dairy products are with no doubt the most studied. In literature little information exists regarding any essential differences in gross composition or other parameters of technological interests in milk from organic or conventional farms. Many authors instead focus on comparing the fatty acids (FA) profile of organic milk to that of conventional milk (Toledo et al., 2002; Bergamo et al, 2003; Ellis et al., 2006; Molkentin et al, 2007; Lavrenčič et al., 2007; Anacker et al., 2007; Collomb et al., 2008). All authors found a lower saturated FA (SFA) concentration and a higher polyunsaturated FA (PUFA) concentration in organic milk compared with conventional milk; only a study of Butler et al. (2008) reported no significant difference in PUFA concentrations between organic and conventional milk. Several studies have investigated the effect of organic farming systems on conjugated linolenic acid (CLA) content of milk, but results differ, with some authors reporting a higher CLA content in organic milk (Molkentin et al, 2007; Bergamo et al, 2003), whereas others reported no difference (Toledo et al., 2002; Ellis et al., 2006).

A clear comparison between organic and conventional quality of products is difficult to establish due to the great variation within the production methods, concerning among other things, intensification, feeding ration or breeds used (Sundrum, 2001). For this it is important that the research on organic milk production should be carried out in each country independently because of the different organic management in each area that should be produce different effect on milk quality (Ellis at al., 2006).

The aim of this study was to compare chemical composition, milk coagulation properties and fatty acids profile of milk obtained from organic and conventional dairy farms located in the same mountain area (Veneto region, NE of Italy).

2.2 MATERIALS AND METHODS

2.2.1 Milk Samples Collection

Ten organic (ORG) and six conventional (CON) dairy farms located in the same mountain area (Belluno province, Veneto region, NE of Italy) were selected for the 12-mo longitudinal study. Organic farms were managed according to the EU Regulation 1804/99 (and following regulation of Italian Ministry of Agriculture, MiPAF) and controlled by ICEA (an accredited control body of organic productions). Conventional farms were selected to have similar herd characteristics (Table 2.1). Herd size was very variable from 2 to 60 milking cows in organic farms and from 12 to 90 milking cows in conventional farms. The average milk yield is lower in conventional farms with respect to organic farms, with high variability among farms.

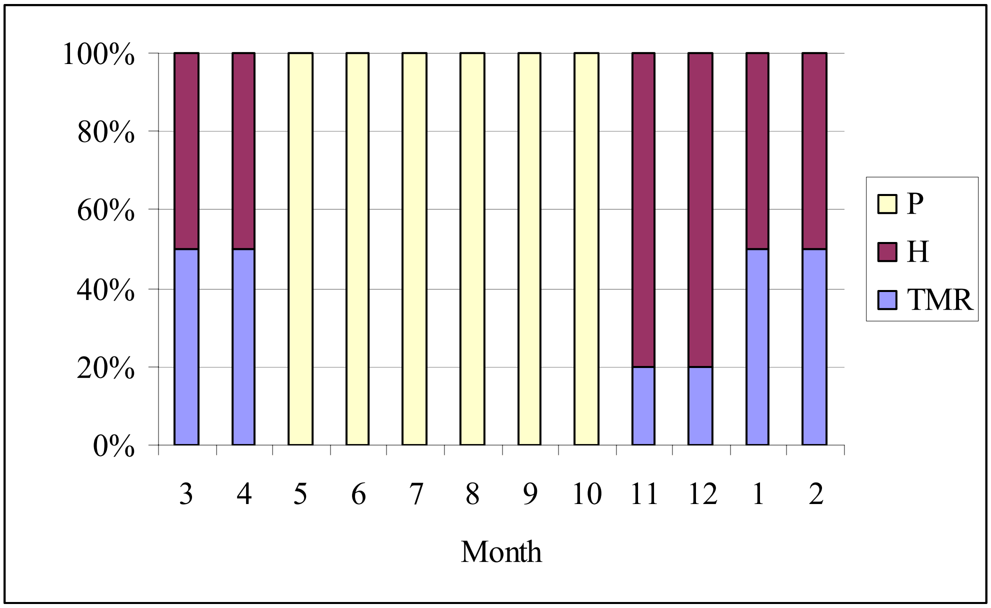
Table 2.1. Description of selected organic and conventional farms (mean values)

Item	Organic	Conventional
Number	10	6
Herd characteristics:		
Herd size (milking cows)	26.8	33.2
Breed, %		
Simmental	50	60
Brown Swiss	40	30
Holstein-Fresian	5	5
Cross-breeds	5	5
Milk yield, kg/d	18.7	16.9

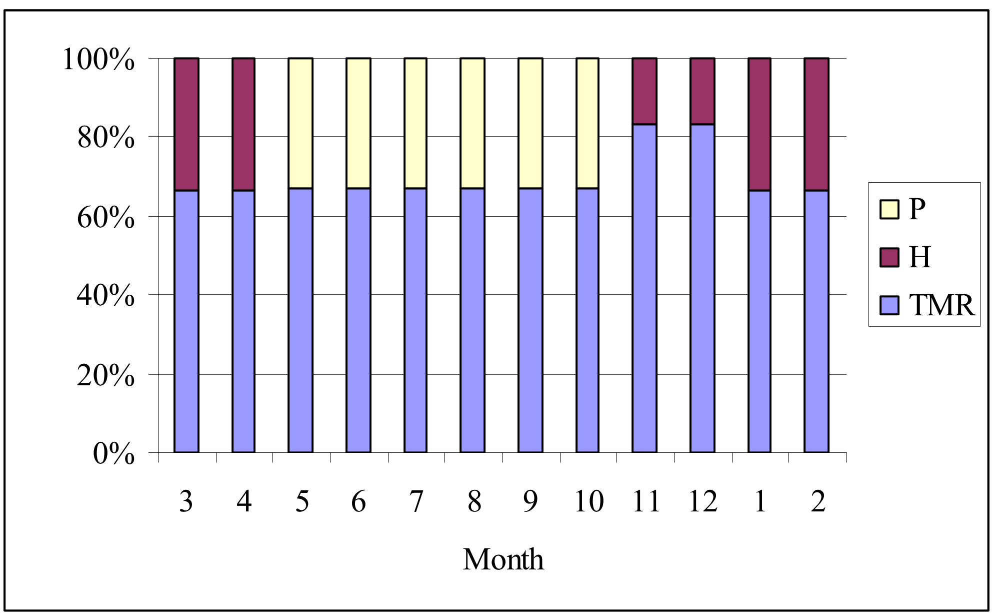
Farm production data were obtained by interview questionnaire draw up by the veterinary and researcher involved in the project. All farms were visited monthly from March 2007 to March 2008. At each farm visit a bulk-tank milk sample was collected into 50-ml plastic containers after stirring the bulk tank. About dietary composition, the farms were classified monthly depending on the management feeding based on Pasture, Hay or Total Mixed Ration (Figure 2.1).

Figure 2.1. Percentage of organic (**a**) and conventional (**b**) farms with management feeding based on Pasture (P), Hay (H) or Total Mixed Ration (TMR) during 12-mo study

a



b



2.2.2 Sample Analysis

A total of 208 milk samples were analysed. Chemical composition (fat, protein, casein and lactose content) of milk was analysed using Midinfrared instruments (IDF, 2000), SCC was obtained using a direct microscopic method according to standard methods proposed by the IDF (1995) and bacterial count was determined by Bactoscan 8000 according to standard method proposed by IDF (1991). Somatic cell and bacterial counts were transformed to somatic cell score (SCS) and log bacterial count (LBC) by base-2 logarithm and natural logarithm respectively. Urea was determined by an enzymatic method using differences in pH (CL10 instrument, Eurochem, Italy). Milk coagulation properties (MCP; milk renneting time, curd firming time and curd firmness) of the milk samples (10 ml) were measured for 31 min by a Computerized Renneting Meter (CRM; Polo Trade, Monselice, Italy). Rennet coagulation time (r, min) is the time from the addition of rennet to the beginning of coagulation, curd firming time ($K_{20,}$ min) describes the time needed until the curd is firm enough to be cut and curd firmness (a_{30}, mm) is the width of the curd 30 min after the addition of rennet (Ikonen et al., 2004). In addition, the pH of the milk samples was measured with a pH meter (Crison Instruments S.A., Barcelona, Spain). Analysis of fatty acid composition of milk samples was performed by the laboratory of the Department of Animal Science (Padova, Italy). Milk fat extraction was based on the method described by Nourooz-Zadeh and Appelqvist (1988). A 17mL milk sample was transferred into a separator funnel, and 30mL of isopropanol were added. After vigorous shaking, 22.5mL of hexane were added, and the mixture was shaken for another 3 min. The mixture was let it stand below extractor fun for 60 min and after that the upper layer was transferred to a second separator funnel. The lower layer was again extracted with 22.5mL of hexane and the supernatant was pooled with the previous hexane layer. After addition of 15mL of 0.47 m aqueous Na2SO4, the hexane layer was collected into a flask and evaporated with a rotary evaporator (BÜCHI R 205, Schweinz, Switzerland) The residue was dissolved in hexane and dried with anhydrous sodium sulfate. The quantification of the lipid was performed by using a micro-balance (Gibertini SRL, Milano). Fatty acid methyl esters were prepared as described by Christie (1982) using methyl decanoate hexane (Sigma-Aldrich, SAFC) as internal standards. Samples of fat solutions in hexane containing 30–40 mg fat were transferred into screw capped test tubes and hydrolyzed to free fatty acids by addition of 2mL internal standard, 0.1mL of methyl acetate, 0.1mL of sodium methoxide 1 M and 0.15mL of termination reactant (ossalic acid in etilic ether solution). The mixture was then centrifuged at 8000 rpm for 10 min and the upper layer was transferred with a Pasteur pipette into vial for GC analysis. Composition analysis of the fatty acids was carried out with an 8000 Top Series gas chromatograph (ThermoQuest Italia S.p.A., Rodano, Italy) fitted with Omegawax 250 fused silica capillary column (30m×0.25mm; Supelco Bellefonte, PA, USA) and a flame ionization detector. Results were transformed to present each individual fatty acid as a percentage of the total fatty acids in the milk fat sample.

2.2.3 Statistical Analyses

Milk chemical composition, coagulation traits and fatty acids composition were analyzed by GLM procedure of SAS Institute (SAS 9.1, 2002).

The statistical analysis was compared carry out using split-plot model considering the farm system (ORG vs CON) and the farm unit the main plot, while the month of sampling and the interaction farming system × month of sampling in the sub-plot. The effect of farm system was tested using an error line based on farm unit nested within farming system.

The level of significance was set to P<0.05, P<0.01 and P<0.001.

2.3 RESULTS AND DISCUSSION

Chemical composition and coagulation traits of milk from organic and conventional farms during the trial are shown in Table 2.2. No significant differences were observed in chemical characteristics between milk obtained in organic and conventional farms. Protein content are on average 3.37%, casein content was on average 74.9% of protein while milk fat content result on average 3.77%. The absence of differences between organic and conventional milk was also obtained by other authors (Toledo et al., 2003; Lund et al., 1990). Recently (Bakutis et al., 2007) reported higher percentage of protein content in organic milk respect to the conventional one, while Anacker et al. (2007) highlight an increase of casein content of about 0.21% in organic milk.

The differences in MUN content, even if high, are not significant. The level of MUN, on average 23.4 mg/100mL, are tolerate even if lower respect to the optimal value (27-30 mg/100ml; Peyraud, 1989). That should be indicating an imbalance of feed ratio in farms, with a surplus of energy combine with deficiency of dietary protein. Toledo-Alonzo (2003) found that organic systems produce milk with lower urea concentrations compared with conventional farms of the same size.

Table 2.2. Least square means of milk type effect and standard error (SE) of milk composition and coagulation traits.

	Farming system		
Item	Organic	Conventional	SE
Milk composition traits			
Protein, %	3.34	3.39	0.02
Casein, %	2.50	2.54	0.03
Fat, %	3.74	3.81	0.02
Lactose, %	4.86	4.89	0.01
MUN, mg/100ml	26.22	20.69	0.66
SCS[1]	2.30	2.41	0.03
LBC[2]	3.61	3.59	0.10
Milk coagulation traits			
r,[3] min	15.91	15.01	0.29
K_{20},[4] min	4.01[a]	5.13[b]	0.16
a_{30},[5] mm	38.36	37.01	0.58

[a,b] Means with different letters differ significantly (P<0.05)
[1] SCS= $\log_2$ of SCC;[2] LBC= natural log of bacterial count ;[3] r= rennet coagulation time;
[4] K_{20}= curd firming time;[5] a_{30}= curd firmness

Production type was not affected by the somatic cell count and bacterial count in milk that results similar. In literature Toledo et al. (2002) found lower content of somatic cell count while Hardeng et al., (2001) did not find any difference regarding sanitary parameters.

Regarding milk coagulation traits, only K_{20} parameter (curd firming type) result significant lower, so more favourable, in organic milk in comparison with conventional one (4.01 vs 5.13 mm; P<0.05). The average value of r (rennet coagulation time) and a_{30} (curd firming time), respectively of 15.46 min and 37.88 mm, results better from a technological point of view in comparison with the values reported in a study about the effect of breed on quality of milk (De Marchi et al., 2008).

The effect of month of sampling results significant only for fat content that results decrease in the first months with the lowest content in August, in according with the repressive effect of pasture intake on milk fat content (Bargo et al., 2002; Croissant et al., 2007). No significant effects of interaction between farm systems and month of sampling were detected among chemical composition and coagulation traits of different type of milk.

The mean percentages of each fatty acids (FA) groups in both organic and conventional milk averaged over the 12-mo of the study is shown in Table 3.

No differences were observed among organic and conventional milk about short-chain FA (from C:4 to C:12) while medium chain FA (from C14:0 to C16:0) content was lower ($P<0.01$) in organic milk compared to conventional one. It follows that the SFA content in organic milk are lower ($P<0.05$) than in conventional milk. From the human health point of view, these results are important seeing that C12:0 (lauric acid), C14:0 (myristic acid) and C16:0 (palmitic acid) have been indicated as the main fatty acids responsible for increasing plasma total and LDL cholesterol concentrations (Antongiovanni et al., 2003).

Organic milk had a significant higher percentage of monousaturated FA (MUFA; 27.9 vs 25.0%; $P<0.05$) and polyunsaturated FA (PUFA; 4.7 vs 4.0%; $P<0.01$). Therefore the ratio saturated/unsaturated FA (2.1 vs 2.5; $P<0.05$) results more favourable in organic milk respect to conventional one.

Many authors reported a lower SFA concentration and a higher PUFA concentration in organic milk compared with conventional milk (Ellis et al., 2006; Anacker et al., 2007; Slots et al., 2009). Butler et al. (2008) reported, instead, no significant difference in PUFA concentration in milk obtained from organic and conventional systems.

There was no difference between systems in the mean of n-6 FA and n-3 FA, so in the n-6: n-3 ratio. This latter result 2.93 in organic milk, similar to the ratio obtained by Thorsdottir et al. (2004) in conventional milk from Iceland, on average 2.10:1, and lower than that n-6: n-3 ratio results from milk from four other Nordic countries, where the ratio averaged 4.70:1. However, the ratio obtained was lower than the advice of FAO/WHO (1994) that suggested an n6:n3 ratio from 5:1 to 10:1.

Table 2.3. Least square means of milk type effect and standard error (SE) of fatty acid (FA; % of total FA) over the 12mo of sampling

	Farming system		
Item	Organic	Conventional	SE
C4:0	4.26	4.27	0.06
C6:0	2.72	2.87	0.04
C8:0	1.62	1.74	0.02
C10:0	3.24	3.58	0.04
C12:0	3.35	3.72	0.04
C14:0	11.09[a]	11.75[b]	0.09
C16:0	26.49[a]	29.72[b]	0.26
C17:0	1.05	1.11	0.01
C18:0	8.71[a]	10.23[b]	0.11
Saturated FA	67.20[a]	70.76[b]	0.27
C16:1 n-7	1.46	1.62	0.02
C18:1 *trans*-11 vaccenic	2.69	2.11	0.08
C18:1 n-9	20.58[a]	18.18[b]	0.19
Monounsaturated FA	27.91[a]	25.00[b]	0.25
C18:2 n-6	2.25[a]	1.89[b]	0.03
C18:3 n-6	0.24	0.23	0.01
CLA[1]	1.10	0.92	0.03
Polyunsaturated FA	4.67[a]	3.98[b]	0.06
SFA/(MUFA+PUFA)	2.10[a]	2.52[b]	0.03
n-6 FA	2.60	2.12	0.03
n-3 FA	0.92	0.77	0.02
n-6/n-3	2.93	3.33	0.08
IA[2]	2.38[a]	2.96[b]	0.04
IT[3]	2.62[a]	3.16[b]	0.04

[a,b] Means with different letters differ significantly ($P<0.05$)
[1] CLA= conjugated linolenic acid
[2] IA= Index of Atherogenicity
[3] IT= Index of Thrombogenicity; (Ulbricht and Southgate, 1991)

Content of vaccenic acid and conjugated linolenic acid (CLA) results similar between the two types of milk. In according with this study Toledo et al. (2002) and Ellis et al. (2006) reported no difference in CLA and vaccenic acid content. This results contrast with many authors that found higher concentration of vaccenic acid and CLA in organic or pasture-based milk (White et al., 2000; Bergamo et al., 2003; Butler et al., 2008).

Even if no significant differences were observed in CLA content, the average value of this parameters was higher (on average 1.01% of total FA) respect to the values reported in literature. Ellis et al. (2006) found a percentage of CLA of 0.65%of total FA in organic and

0.58% of total FA in conventional milk. In milk from cows fed with 100% of forage from pasture, French et al. (2000) found a percentage of 1.08% of total FA of CLA.
Both indexes of nutritional interests (Atherogenicity and Thrombogenicity indexes) result more favourable in organic milk.
Similar concentration of n-3 FA and CLA were found by Molkentin et al. (2007), while Ellis et al. (2006) reported an higher content in n-3 FA while CLA content and vaccenic acid results similar between organic and conventional milk.
A significant effect ($P<0.001$) of month on the proportion of FA in both organic and conventional milk was observed (Figure 2.3;2.7). A pronounced seasonal variation can be seen and is the same for both types of milk and are in agreement with earlier study (Collomb et al., 2008; Ellis et al., 2006).
The interaction between month of sampling and farming systems was not significant for any groups of FA. SFA proportion decreased in the spring and summer, with the lowest value in June for organic milk, and increased value in the fall and winter months (Figure 2.3a). Opposite trends were observed for MUFA and PUFA content, whit higher proportion of unsaturated FA in the summer period (May-September; Figure 2.3b and 2.4a). Ratio of saturated/unsaturated FA remains lower in organic milk for the whole 12 months (Figure 2.4b).
The month effect reflects changes in the composition of diet. From May to October the total organic animals were at the pasture, but also about 30% of conventional farms (Figure 2.1). The decrease of SFA content in summer months is linked with an increase of PUFA content in fresh grass during summer grazing. Fresh pasture contains a high percentage of unsaturated FA with α-linolenic acid the main n-3 FA (Dewhurst et al., 2001). Higher value of MUFA and PUFA in the spring and summer correspond with the access of pasture and the cow's intake of fresh grass.
The significant effect of month on n-3 and n-6 FA showed a highest n-3 and n-6 content in September in milk, while no significant month effect were detected for n-6/n-3 ratio (Figure 2.5). The n-6:n3 ratio in organic milk ranged from 2.58 to 3.31, and in conventional milk ranged from 2.89 to 4.41. An increase of vaccenic acid was recorder in spring and summer until September when the vaccenic acid content in milk decrease (Figure 2.6a). Vaccenic acid content remains higher in organic milk during whole period. The trend of

content of CLA was similar, with peak in September that dropped in October (Figure 2.6b). The milk CLA content and vaccenic acid, which are intermediate products of biohydrogenation of FA, was strongly linked with the month of sampling, with a significant increase in the spring and summer month due to the access of pasture by cows. Many researches reported the increase CLA content in cows at pasture (Dhiman et al., 1999; Agenas et al., 2002; Croissant et al., 2008). Atherogenic and Thrombogenic indexes follow the same trend with lower value in organic milk compared with the conventional one during all months (Figure 2.7).

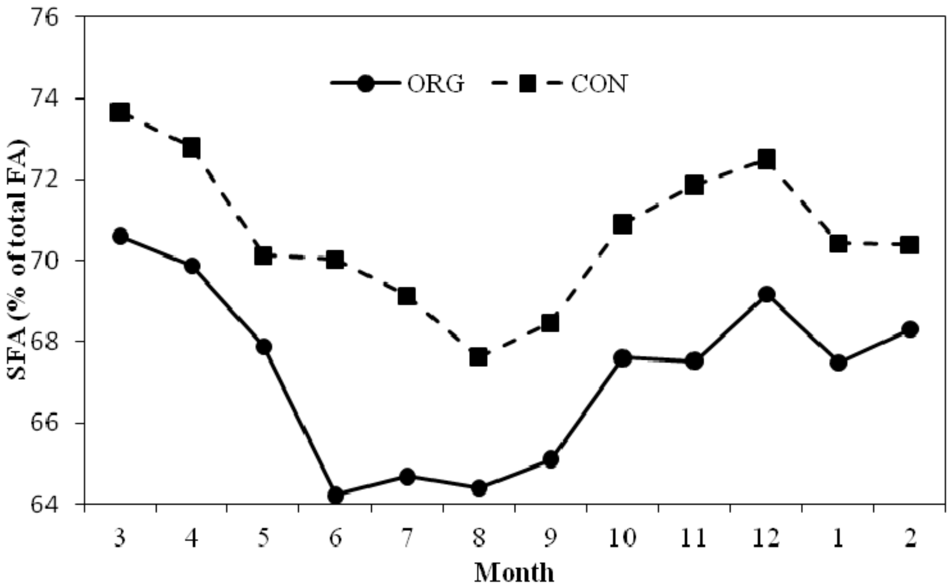
In conclusion this study confirmed a similar chemical composition of milk obtained from organic and conventional milk. A higher proportion of unsaturated FA was observed. CLA content resulted very higher both in milk from organic and conventional farm located in the mountain area respect to the value reported in literature. In this study the overall production systems were considered but the effect of single diet factor, pasture-based diet, seems to be more influenced the quality of milk, in particular FA profile.

Acknowledgment

This experiment is a part of large regional project called “Biobos” supported by the Veneto Region about quality and nutritional characteristics of dairy and beef production from organic and conventional systems in the mountain area.

Figure 2.3. a) Percentages of saturated fatty acids (SFA); **b**) monounsaturated FA (MUFA) in organic (●) and conventional (■) milk during 12-mo study (month 3=March 2007 and month 2=February 2008). Mean values are taken across all farms of each production system type.

a



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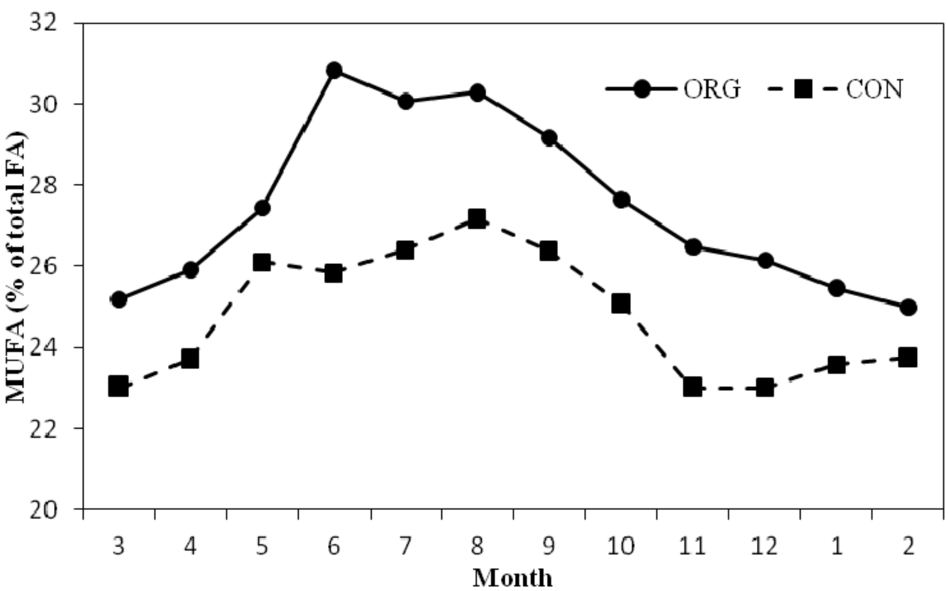
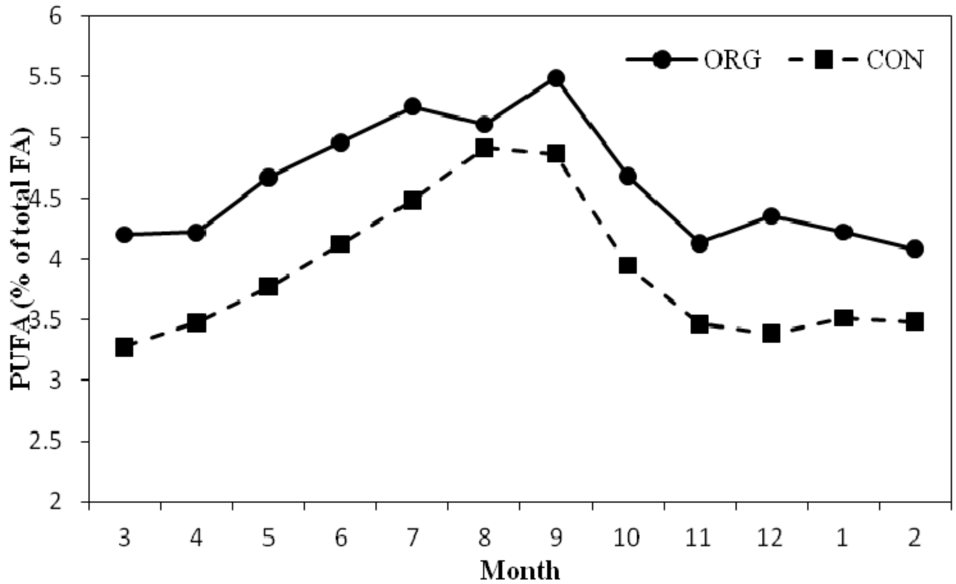


Figure 2.4. **a**) Percentages of polyunsaturated FA (PUFA); **b**) ratio of SFA to MUFA+PUFA in organic (●) and conventional (■) milk during 12-mo study (month 3=March 2007 and month 2=February 2008). Mean values are taken across all farms of each production system type.

a



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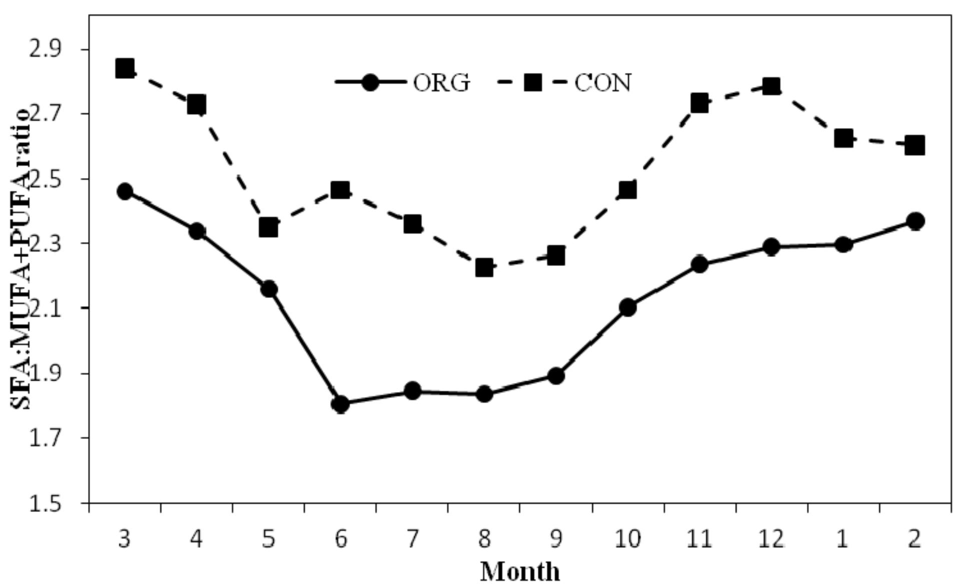


Figure 2.5. a) Percentages of n-3 fatty acids **b**) n-6 fatty acids **c**) ratio of n-6:n-3 FA in organic (●) and conventional (■) milk during 12-mo study (month 3=March 2007 and month 2=February 2008). Mean values are taken across all farms of each production system type.

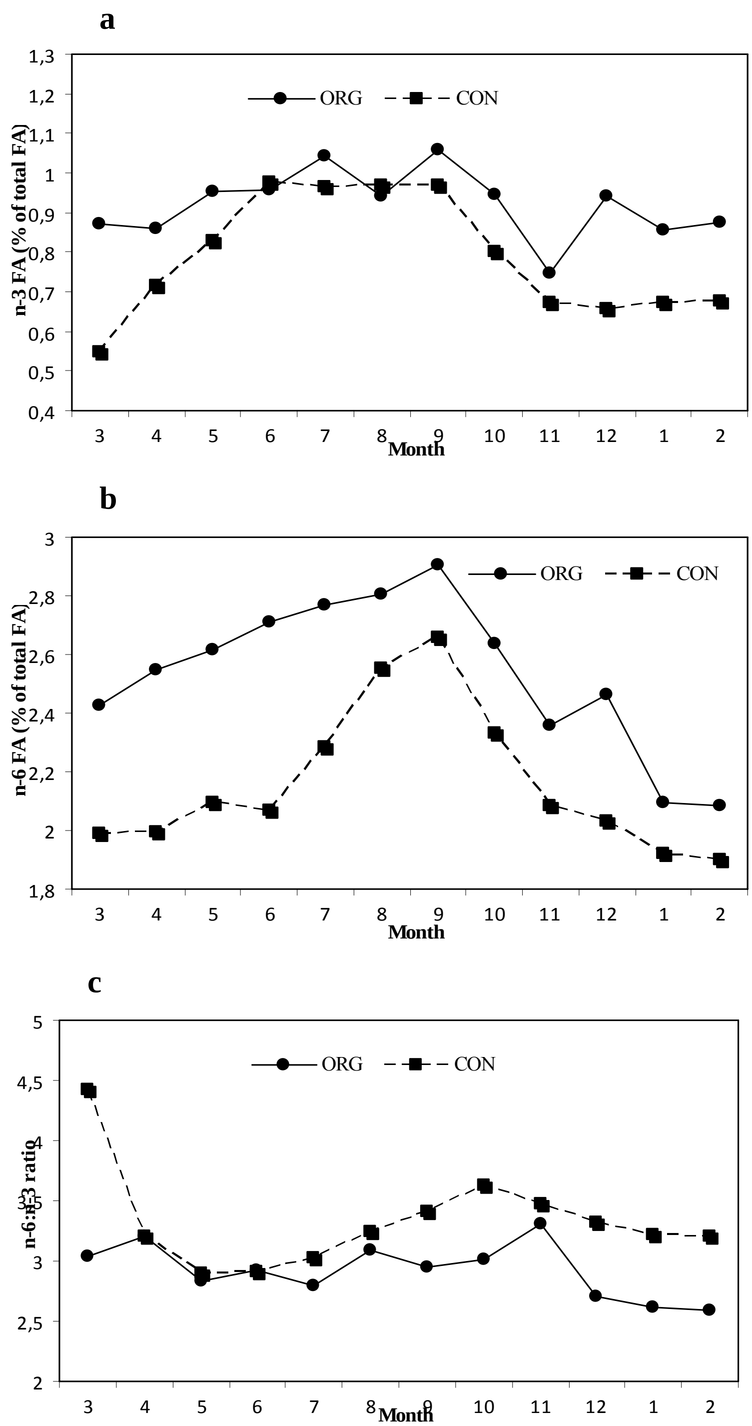


Figure 2.6. **a**) Percentage of vaccenic acid; **b**) percentage of conjugated linolenic acid (CLA) in organic (●) and conventional (■) milk during 12-mo study (month 3=March 2007 and month 2=February 2008). Mean values are taken across all farms of each production system type

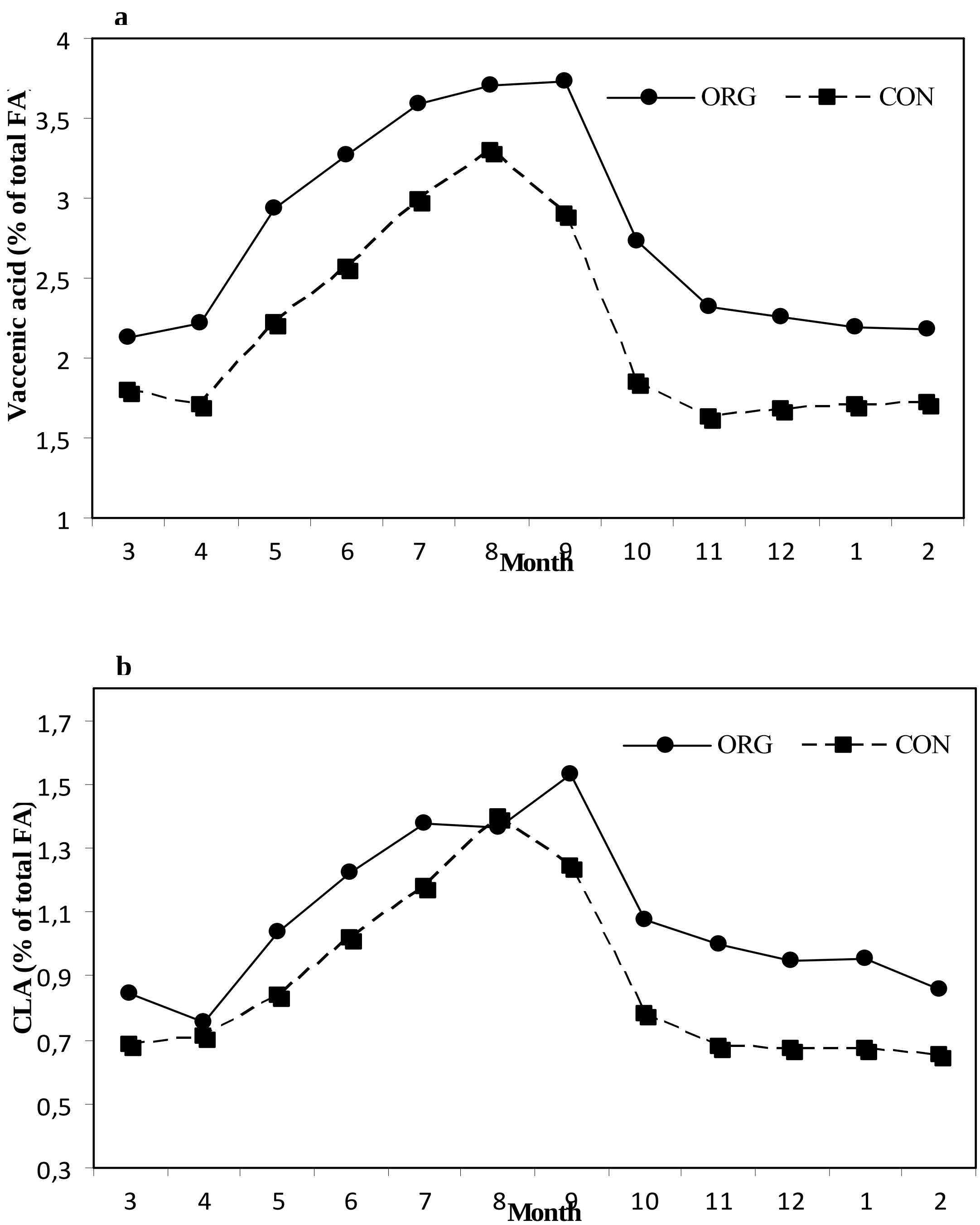
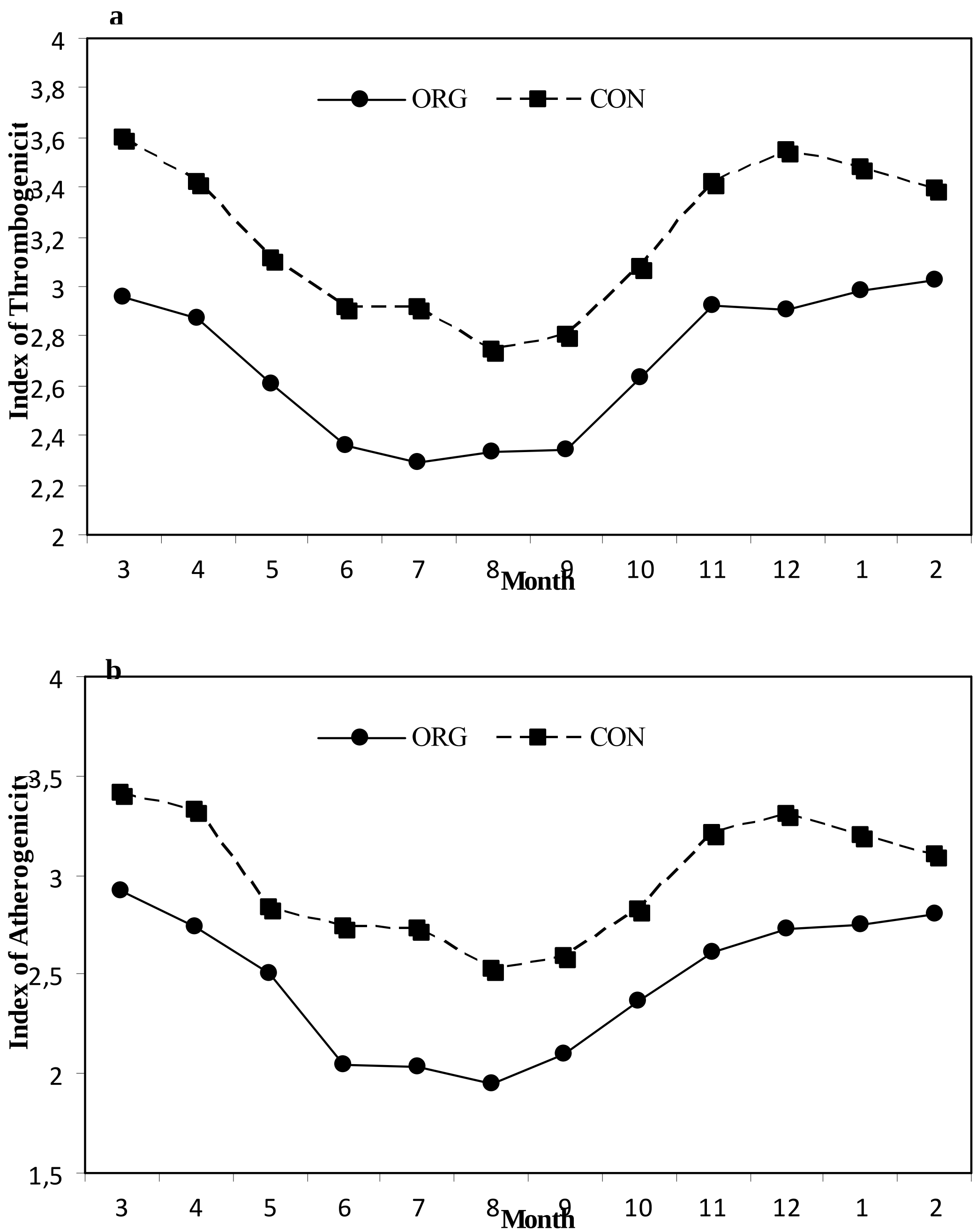


Figure 2.7. a) Index of Thrombogenicity; **b**) index of Atherogenicity in organic (●) and conventional (■) milk during 12-mo study (month 3=March 2007 and month 2=February 2008). Mean values are taken across all farms of each production system type



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CHAPTER 3

Chemical composition, fatty acids profile and sensory properties of cheese from organic and conventional milk

Study results presented at the EAAP – 59th Annual Meeting,

Vilnius, Lituania. 24-27 August 2008

3.1 INTRODUCTION

The recent European Regulation (EC Regulation 889/2008) promotes 100% organic feeding of the organic dairy cows and remarks the required access to pasturage for grazing whenever conditions allow. Pasture-based diets supply a significantly higher level of unsaturated fatty acids compared with diets based on the unified in the intensive systems and this reflects in a higher concentration of unsaturated fatty acids in the milk fat (Bargo et al., 2006; Couvreur et al., 2006; Croissant et al., 2007). Milk fat composition had a significant effect on the cheese fat compositional variability regarding all fatty acids (Lucas et al., 2005). Several studies were performed to compare milk quality of organic and conventional milk (Collomb et al., 2008; Ellis et al., 2006; Toledo et al., 2002) but there is a lack of information about the compositional and sensorial difference between organic and conventional dairy products, especially obtained in the mountain area. To fill this gap the aim of this study was to determine possible variations in chemical and fatty acid composition and sensorial properties of cheeses from organic and conventional dairies located in the mountain area over a whole year. Another purpose of this trial was to verify the possibility to distinguish cheeses obtained by milk produced from different production systems.

3.2 MATERIALS AND METHODS

3.2.1 Vat Milk and Cheese Samples

The study involved three dairies located in the same homogeneous mountain area in the Veneto region (North-East of Italy). In one dairy, cheeses were manufactured using only organic milk obtained from certified organic farms located in the *Cansiglio Plateau* (Belluno province, Veneto region), while in the other two the milk used was obtained from conventional farms located in the same area. The dairies were similar for cheese making process and type of cheese produced (Table 3.1).

The vat milk was sampled monthly from March to February of the subsequent year, and the same milk was used to manufacture the pressed uncooked cheeses (typical Veneto semi hard cheese, called *Latteria*). These cheeses were sampled after three months of ripening under the same environmental conditions.

Table 3.1. Techniques and cheese-making parameters in the dairies considered in the study

Dairy	Milk type	Milk characteristics	Total milk processed (q/d)	Starter cultures	Milk pH	Cooking temperature(°C)	Salting method
ORG	organic	raw, whole	36	yes	3.5	45	brining
CON1	conventional	raw, whole	15	yes	3.5	44	brining
CON2	conventional	raw, whole	15	yes	4	45	brining

3.2.2 Vat Milk and Cheese Analyses

Chemical composition (fat, protein, casein and lactose content) of vat milk was analysed using Midinfrared instruments (IDF, 2000). Somatic cell count was obtained using a direct microscopic method according to standard methods proposed by the IDF (1995) and bacterial count was determined by Bactoscan 8000 according to standard method proposed by IDF (1991). Somatic cell and bacterial counts values were transformed to somatic cell score (SCS) and log bacterial count (LBC) by base-2 logarithm and natural logarithm respectively.

Milk coagulation properties (MCP; milk renneting time, curd firming time and curd firmness) of the milk samples were measured for 31 min by a Computerized Renneting Meter (Polo Trade, Monselice, Italy). Rennet coagulation time (R, min) is the time from the addition of rennet to the beginning of coagulation, curd firming time (k_{20}) describes the time needed until the curd is firm enough to be cut and curd firmness (a_{30}, min) is the width of the curd 30 min after the addition of rennet (Ikonen et al., 2004).

Cheese samples were analysed for moisture content by drying at 102°C (IDF, 2004), for fat content using the Van Gulik method (IDF, 2008), for total protein using Kjeldhal method (IDF, 2001) and for NaCl content with conductometric method.

Levels of retinol and α-tocopherol in milk and cheese samples were determined using HPLC followed by Zahar and Smith (1990) and Indyk (1990) procedures, opportunely modified.

Analysis of macroelements (Ca, P, Mg, Na, K) and microelements (Zn, Cu, Fe) in milk and cheese samples was made using inductively coupled plasma atomic emission spectrometry (ICP-AES) after microwave digestion (Ethos, Milestone, Monroe, CT, USA).
Colour was determined in cheese with a colorimeter (Spectrophotometer CM-508, Minolta, Germany) according to the method of CIELAB (1976).
Analyses of fatty acid composition were performed by the laboratory of Department of Animal Science (Padova, Italy). Milk and cheese fat extraction was based on the method described by Nourooz-Zadeh and Appelqvist (1988). A 17mL of milk or 2g of cheese sample was transferred into a separator funnel with the addition of 15mL of distilled water, and 30mL of isopropanol were added. After vigorous shaking, 22.5mL of hexane were added, and the mixture was shaken for another 3 min. The mixture was let it stand below extractor fun for 60 min and after that the upper layer was transferred to a second separator funnel. The lower layer was again extracted with 22.5mL of hexane and the supernatant was pooled with the previous hexane layer. After addition of 15mL of 0.47 *M* aqueous Na_2SO_4, the hexane layer was collected into a flask and evaporated with a rotary evaporator (BÜCHI R 205, Schweinz, Switzerland). The residue was dissolved in hexane and dried with anhydrous sodium sulfate. The quantification of the lipid was performed by using a micro-balance (Gibertini SRL, Milano). Fatty acid methyl esters were prepared as described by Christie (1982) using methyl decanoate hexane (Sigma-Aldrich, SAFC) as internal standards. Samples of fat solutions in hexane containing 30–40 mg fat were transferred into screw capped test tubes and hydrolyzed to free fatty acids by addition of 2mL internal standard, 0.1mL of methyl acetate, 0.1mL of sodium methoxide 1 M and 0.15mL of termination reactant (ossalic acid in etilic ether solution). Then the mixture was centrifuged at 8000 rpm for 10 min and the upper layer was transferred with a Pasteur pipette into vial for gas chromatography analysis.
Composition analysis of the fatty acids was carried out with an 8000 Top Series gas chromatograph (ThermoQuest Italia S.p.A., Rodano, Italy) fitted with Omegawax 250 fused silica capillary column (30m ×0.25mm; Supelco Bellefonte, PA, USA) and a flame ionization detector. Results were transformed to present each individual fatty acids as a percentage of the total fatty acids in the cheese fat sample.

Sensory profile of the ripened cheese was evaluated by a panel of 10 assessors following the official standards (ISO, 2003). To choose the sensory attributes, the panelists were trained to evaluate commercial cheese (ISO, 1993; ISO, 2008) and to recognize certain attributes with reference materials and recommended by Bérodier et al. (1997). The following eleven attributes of odour, aroma and taste were chosen: intensity of smell, intensity of aroma, sweetness, saltiness, acidity, bitterness, strong, hardness, friable, soluble and humidity. Cheese samples were presented as 1.5 cm thick × 1.5 cm wide × 5–8 cm long portions, without 1.5 cm of rind. Two portions per sample were served at 14±2 °C. Attributes were scored using a scale ranging from 1 (very slight perception) to 7 (very intense) anchored with standard food references (Lavanchy et al., 1999). Unsalted crackers and water were served to remove any aftertaste between samples were used. Tests were conducted in individual cubicles under standard lighting.

3.2.3 Statistical Analysis

A two-factors (dairy and month of sampling) ANOVA was performed on chemical data, fatty acids and sensory profile using GLM procedure of SAS Institute (2002) using the following model:

$$y_{ijk}= \mu + D_i + M_j + DM_{ij} + \varepsilon_{ijk}$$

where y_{ijk}=observed variable, μ = the overall mean, D_i = dairy effect (i=1,..,3), M_j = month of sampling effect (j=1,..,12), DM_{ij} = interaction between dairy and month of sampling time, ε_{ijk} = residual error.

Orthogonal contrasts were carried out to study the differences between the two types of cheese (obtained from organic and conventional milk; ORG vs CON) and between the two conventional cheeses (obtained from conventional 1 and conventional 2 dairies; CON 1 vs CON 2). The level of significance was set to $P<0.05$, $P<0.01$, $P<0.001$.Principal component analysis (PCA) was performed using SIMCA-P11 Software (Umetrics, Umeå, Sweden) by factorial data reduction extracting 2 factors. The first and second components were calculated as independent variables on data by linear regression analysis. PCA was carried out on fatty acids composition that was found to be influenced by the type of cheese.

3.3 RESULTS AND DISCUSSION

No significant month effect and interaction between dairy and month effects were found about chemical composition of vat milk and cheese. Month effect resulted significant only for FA profile and were discussed through PCA analysis results.

3.3.1 Composition of Vat Milk

Chemical composition of vat milk was similar in organic and conventional systems except for the protein content. This parameter was lower in organic milk respect to the conventional ones ($P<0.01$; Table 3.2). No significant differences in chemical composition was also found by Toledo (2002), while in some studies the protein content in organic milk resulted higher (Lund et al., 1990; Bakutis et al., 2007) or lower (Trachsen et al., 2000; Anacker et al., 2007) with respect to the milk obtained from conventional farms. Fat content resulted different only between the conventional vat milk, due to the occasional skimmer of vat milk in CON2 dairy. In our study organic production systems (based on pasture) did not show the well-known repressive effects on milk fat content (White et al., 2001; Bargo et al., 2002; Croissant et al., 2007). SCS and LBC were similar in milk obtained from organic and conventional farms and always lower than the limit reported in the law for production of high quality milk. A significant difference was found in SCS content between conventional vat milk. The content of retinol (vitamin A) was lower in organic vat milk with respect to the conventional ones (2.15 vs 2.71μg/g fat; $P<0.01$) while the α-tocopherol (vitamin E) content was higher in organic milk compared to the conventional ones (2.52 vs 1.71 μg/g fat; $P<0.001$). These effects could be explained by the differences in feeds and feeding regimen between the two production systems; indeed, fresh grass from the grazing activity in organic feeding improved the α-tocopherol content in organic milk (Havenose et al., 2004). On the contrary the higher content of retinol in conventional vat milk can be justify by the inclusion of synthetic vitamin A in mixed feeds used in conventional system, not allowed in organic farming. Higher content of A and E vitamins was observed in organic milk by several studies (Toledo et al., 2003; Nielsen et al., 2004; Slots et al., 2008) while Emanuelson et al. (2007) did not find significant differences in vitamin levels between milk from two systems.

Mineral profile resulted similar among the vat milk; slight differences in K content between conventional milk were found (P<0.05).

Milk coagulation traits were similar between organic and conventional vat milk and also the milk acidity parameters (titratable acidity), strongly correlated (Remeuf and Hurtaud, 1991).

Table 3.2. Least square means (LSM), contrasts and root mean square error (RMSE) of chemical and physical traits of vat milk obtained from organic (ORG) and conventional (CON1 and CON2) farms.

	LSM			Contrasts			
Traits	ORG	CON1	CON2	ORG vs CON	CON1 vs CON2	RMSE	R^2
Milk quality							
Fat, %	3.26	3.43	2.43	NS	**	0.67	0.50
Protein, %	3.30	3.50	3.34	**	***	0.09	0.68
Lactose, %	4.88	4.80	4.88	NS	NS	0.12	0.51
Casein, %	2.47	2.60	2.46	NS	NS	0.11	0.52
Titratable acidity, °SH[1]/50ml	3.02	2.99	3.10	NS	NS	0.24	0.75
SCS[2], score	6.33	7.59	4.21	NS	***	1.81	0.58
LBC[3], score	3.86	3.17	3.73	NS	NS	0.73	0.76
Vitamin content, µg/g fat							
Vitamin A (retinol)	2.15	2.77	2.66	**	NS	0.45	0.48
Vitamin E (α-tocopherol)	2.52	1.48	1.95	***	*	0.49	0.71
Mineral content, mg/100g							
Ca	116.80	116.75	115.96	NS	NS	3.07	0.35
P	84.82	86.02	85.50	NS	NS	4.68	0.42
Mg	10.28	10.20	9.99	NS	NS	0.41	0.25
K	146.52	144.38	149.93	NS	*	4.67	0.42
Zn	0.53	0.53	0.49	NS	NS	0.07	0.38
Cu	0.10	0.11	0.12	NS	NS	0.03	0.80
Fe	0.33	0.37	0.37	NS	NS	0.19	0.32
Coagulation traits							
r[4]	14.97	15.37	16.00	NS	NS	2.40	0.57
k_{20}[5]	4.45	5.50	4.95	NS	NS	1.66	0.57
a_{30}[6]	38.75	36.92	35.5	NS	NS	5.72	0.61

[1]°SH= Soxhlet-Henkel degree.
[2]SCS= $\log_2$ of SCC;[3]LBC=natural log of bacterial count.
[4]r=rennet coagulation time;[5]K_{20}=curd firming time;[6]a_{30}= curd firmness.
P*<0.05;*P*<0.01;****P*<0.001.

3.3.2 Composition of Cheeses

The composition of cheeses obtained from organic and conventional vat milk is shown in Table 3.3. Fat content of organic cheese was higher than conventional ones (30.94% vs 29.45%; $P<0.05$). The lowest fat content was detected in CON2 cheese due to the low fat content in vat milk.

No differences were detected in organic cheese protein content and the value was intermediate between the two conventional ones. Organic cheese showed a lower percentage of moisture (36.38% vs 37.63%; $P<0.05$).

The NaCl content was higher in the CON2 cheese probably because of the different saltiness degree in the brine used.

The retinol and α-tocopherol content in cheese depended almost exclusively on that originally present in milk fat (Lucas et al., 2005); in fact organic cheese showed lower content of vitamin A and higher content of vitamin E in comparison with conventional samples. The α-tocopherol affect the cheese color, in fact in organic cheese redness and yellowness indexes were significant higher ($P<0.001$) than in conventional ones. Similar results about redness index were obtained by Carpino et al. (2004) in pasture Ragusano cheeses at 4 months of ripening, while yellowness index resulted lower compared with our study data. In general yellow cheese is preferred by the consumers of mountain products, because the yellowness is linked with the pasture-based systems (De Marchi et al., 2008) Cheese lightness resulted different ($P<0.001$) only between the two conventional cheeses.

The mineral profile of cheeses is strongly related to the cheese-making process (Lucas et al., 2005). Ca content and Ca/P ratio (1.5 on average) were similar among cheeses and in line with the nutritional guidelines in similar type of cheese (INRAN, 2007).

The significant higher ($P<0.01$) K content in organic cheese is correlated with the lower moisture content, in fact in cow's milk K is mainly in soluble form (Le Graet et al.,1993).

Copper content resulted significantly different among cheeses (0.56, 0.74 and 0.86 mg/100g respectively for ORG, CON1 and CON2) respectively; $P<0.001$). Considering that Cu content in original milk was similar, the differences in cheese Cu content could be due to the migration of this compound from vats lined with copper, in conventional dairies, during cheese making process. The copper leaching phenomenon has been widely studied, especially about parmigiano reggiano and grana padano cheese making (Cabrera et al., 1996; Bottazzi et al., 2000; Panari et al., 2000).

Table 3.3 Least square means (LSM), contrasts and root mean square error (RMSE) of chemical and physical traits of different cheeses obtained from organic (ORG) and conventional (CON1 and CON2) farms.

	LSM			Contrast			
Traits	ORG	CON1	CON2	ORG vs CON	CON1 vs CON2	RMSE	R^2
Chemical traits							
Fat, %	30.94	30.46	28.45	*	**	1.74	0.49
Protein, %	27.47	26.75	28.72	NS	*	1.71	0.41
Moisture, %	36.38	38.01	37.25	*	NS	1.43	0.51
NaCl, %	1.92	1.62	2.45	NS	***	0.32	0.72
Vitamin content, μg/g fat							
Vitamin A (retinol)	2.27	2.87	3.07	***	NS	1.23	0.51
Vitamin E (α-tocopherol)	2.34	1.91	1.61	***	NS	1.57	0.70
Mineral content, mg/100g							
Ca	890.22	848.81	866.35	NS	NS	66.08	0.36
P	595.70	573.38	602.91	NS	NS	38.60	0.45
Mg	42.27	42.42	39.15	NS	NS	3.94	0.79
K	152.47	136.02	141.39	**	NS	13.51	0.59
Zn	4.39	4.24	4.19	NS	NS	0.31	0.66
Cu	0.56	0.74	0.86	***	*	0.11	0.75
Fe	1.64	1.36	1.57	NS	NS	0.27	0.80
Physical traits							
L*	79.88	83.45	80.23	NS	***	1.69	0.70
a*	2.67	0.85	1.03	***	NS	0.32	0.93
b*	20.78	13.60	15.83	***	***	1.23	0.93

*P<0.05;**P<0.01;***P<0.001.

3.3.3 Fatty Acids Composition of Milk and Cheese

Both milk and cheese obtained from organic dairy farms showed significant differences in fatty acids profile with respect to milk and cheese derived from conventional farms (Table 3.4).

Table 3.4. Least square means (LSM), contrast and root mean square error (RMSE) of milk and cheese fatty acids (FA, % of total FA) composition.

	LSM			Contrast			
Fatty acid	ORG	CON1	CON2	ORG vs CON	CON1 vs CON2	RMSE	R^2
Milk							
Saturated FA	68.23	71.67	71.58	***	NS	2.08	0.62
Monounsaturated FA	26.77	24.67	23.92	***	NS	1.77	0.62
Polyunsaturated FA	4.47	3.22	3.92	***	**	0.49	0.70
SFA/(MUFA+PUFA)	2.22	2.59	2.58	***	NS	0.25	0.60
n-6 FA	2.85	2.28	2.37	***	NS	0.34	0.58
n-3 FA	0.71	0.37	0.77	**	***	0.13	0.77
n-6/n-3	4.01	6.38	3.31	*	***	1.12	0.71
C18:1 *trans*-11vaccenic	2.34	1.89	1.59	***	**	0.34	0.69
CLA[1]	0.83	0.51	0.71	***	**	0.13	0.71
Δ9 desaturation index[2]	34.76	31.56	31.17	***	*	1.69	0.70
IA[3]	2.49	3.03	3.05	***	NS	0.31	0.66
IT[4]	3.15	3.73	3.68	***	NS	0.26	0.72
Cheese							
Saturated FA	66.35	71.01	70.70	***	NS	1.24	0.88
Monounsaturated FA	27.56	24.62	24.10	***	NS	1.14	0.85
Polyunsaturated FA	4.55	3.24	3.90	***	***	0.27	0.89
SFA/(MUFA+PUFA)	2.09	2.56	2.53	***	NS	0.14	0.87
n-6 FA	2.73	2.27	2.34	***	NS	0.20	0.83
n-3 FA	0.73	0.38	0.76	***	***	0.09	0.87
n-6/n-3	3.79	6.54	3.12	**	***	0.88	0.85
C18:1 trans-11vaccenic	2.59	1.62	1.93	***	*	0.33	0.78
CLA[1]	0.92	0.51	0.69	***	**	0.13	0.79
Δ9 desaturation index[2]	35.42	31.71	31.40	***	NS	1.20	0.87
IA[3]	2.38	2.98	2.99	***	NS	0.18	0.88
IT[4]	2.76	3.46	3.21	***	**	0.17	0.89

[1] CLA= conjugated linolenic acid

[2] Δ9 desaturation index=100×[($C_{14:1}$+$C_{16:1}$+$C_{18:1}$+CLA)/($C_{14:1}$+$C_{16:1}$+$C_{18:1}$+CLA+$C_{14:0}$+$C_{16:0}$+$C_{18:0}$+trans-11 $C_{18:1}$)]

[3] IA= Index of Atherogenicity ;

[4] IT= Index of Thrombogenicity; (Ulbricht and Southgate, 1991)

P*<0.05;*P*<0.01;****P*<0.001.

The fatty acids composition in cheese depends directly on the milk fat composition and the cheese making process does not modify the composition original present in milk fat (Lucas et al., 2005). Several studies reported the negligible effect of the cheese making process on the fatty acids composition of cheese (Jiang et al., 1997; Gnådig et al., 2004; Lucas et al., 2005).

The content of saturated FA (SFA) was significantly lower (P<0.001) both in organic milk and cheese with respect to the conventional ones, while monounsaturated (MUFA) and polyunsaturated FA (PUFA) in organic products were significantly (P<0.001) higher. Significant differences in PUFA were also detected between the conventional cheeses. Several studies reported a lower SFA concentration and a higher PUFA concentration in organic milk compared to conventional milk (Kraft et al., 2003; Ellis et al., 2006; Slots et al., 2008). Differently, Butler et al. (2008) did not find significant differences in PUFA concentration between organic and conventional milk.

The content of n-6 FA was significantly higher (P<0.001) in organic milk and cheese. On the contrary a lower level of n-3 FA was detected in CON1 vat milk and cheese. For this reason the highest n6/n3 ratio (6.38 and 6.54, respectively for milk and cheese) was observed in CON1 products. In previous studies a lower ratio of n6/n3 FA has been also found in conventional milk with respect to organic milk (Slots et al., 2009; Collomb et al., 2008; Ellis et al., 2006). Simopoulos (2002) suggested that an n-6:n-3 ratio of 1:1 is appropriate to human diet, with a range from 4:1 to 1:1 on the basis of individual conditions. FAO/WHO (1994) suggested an n6/n3 ratio higher, with a range from 5:1 to 10:1.

In our study vaccenic acid content of milk and cheese was significantly (P<0.001) higher in organic products. Organic milk and milk from pasture-based production systems have been linked to higher concentration of vaccenic acid by other authors (Butler et al., 2008; Croissant et al., 2007; Bergamo et al., 2003). Vaccenic acid is a precursor of the endogenous synthesis of CLA in the mammary gland, the way of greater CLA production in ruminants. In addition CLA concentration in organic milk and cheese was significantly higher (0.83% vs 0.61 % of total FA in milk and 0.92 vs 0.60 % of total FA in cheese; P<0.001) than that measured in conventional ones. Influence of milk processing on CLA in dairy products is controversial (Bergamo et al., 2003). Several authors found no changes in the CLA content during cheese manufacturing process (Dhiman et al., 1999; Gnådig et al., 2004; Khanal et al., 2005;) but others reported CLA instability during processing and storage (Shanta et al., 1992; Garcia-Lopez et al., 1994;).

The CLA content in organic milk and cheese samples was higher with respect to CLA content in milk from conventional cows fed TMR (Kahal et al., 2005). The CLA percentage found in our organic milk sample is similar or lower respect to the milk CLA content of cows grazing on pasture, observed by other authors (Dhiman et al., 1999; White et al., 2001; Kahal et al., 2005). Few studies, instead, did not find effect of organic systems on the composition of CLA in milk (Slots et al., 2009; Ellis et al., 2006).

Highest Δ9 desaturation index ($P<0.001$) associated with a lowest atherogenicity and thrombogenicity indexes ($P<0.001$) in organic productsindicate a better FA profile in organic milk and cheese that has a beneficial nutritional impact for the consumer (Ulbricht and Southgate, 1991).

All data on fatty acids composition were analysed by PCA in order to verify the possibility to identify the origin of the product and/or the production systems. The score plot including all analyzed samples during 12-mo study is reported in Figure 3.1a. The first principal component (PC1) explained 39.6% of variation, while the second principal component (PC2) explained 14.5% of variation. The score plot in combination with loading plot displayed two separated groups (Figure 3.1b). Cheese obtained from organic milk had a significantly higher concentration of n-6 FA, MUFA, PUFA, vaccenic acid and CLA and showed a negative loading for PC1. On the other hand conventional cheeses showed positive loadings for PC1 with higher concentration of SFA, higher n6/n3 ratio and higher IA and IT.

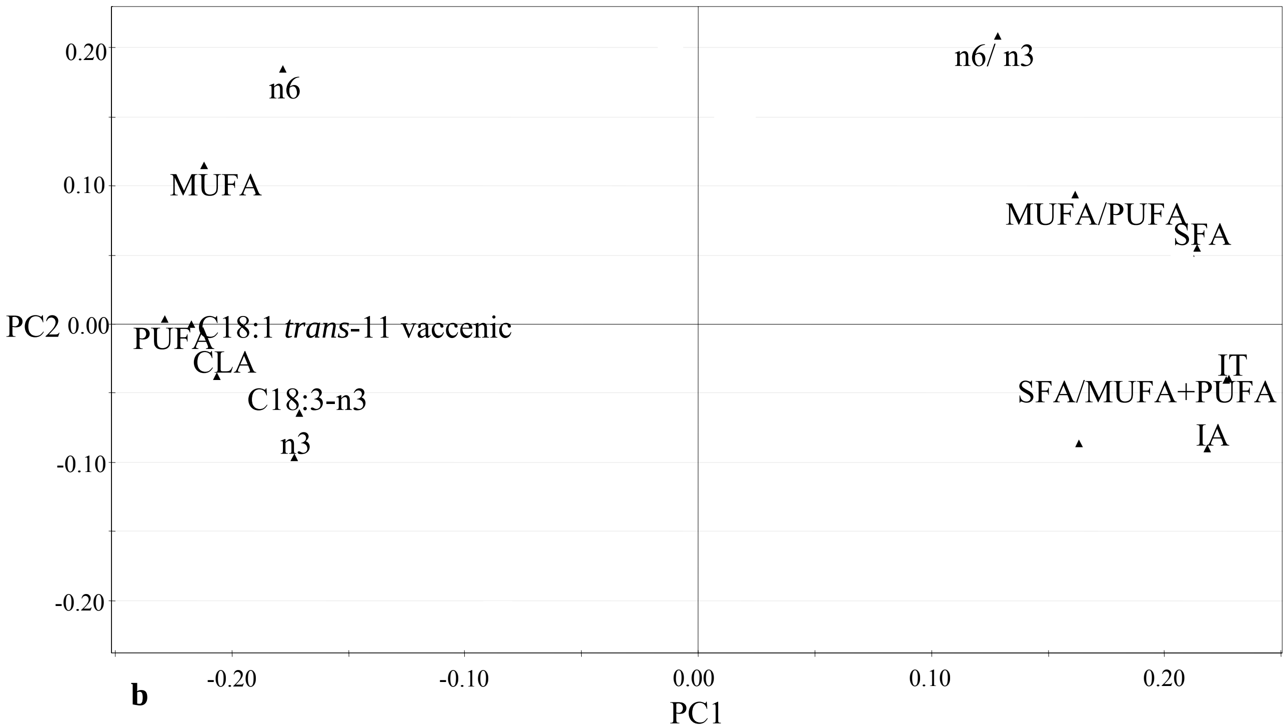
Between organic samples is also possible to distinguish cheeses obtained from milk produced in different months. Cheeses obtained in spring and summer seasons (from April to August) are clearly set apart from organic cheeses produced during winter months and this latter are similar to cheeses produced in CON2 dairy. The differences are due to the higher concentration of n-3 FA, PUFA and CLA in milk produced during the grazing period (late spring and summer). The significant seasonal variation for most of milk FA was widely studied in literature (Butler et al., 2008; Dunshea et al., 2008; Ellis et al., 2006).

Figure 3.1. Principal component analysis of the discriminant fatty acids composition. Component 1 explain the 39.3% of the variance, component 2 the 14.5%.

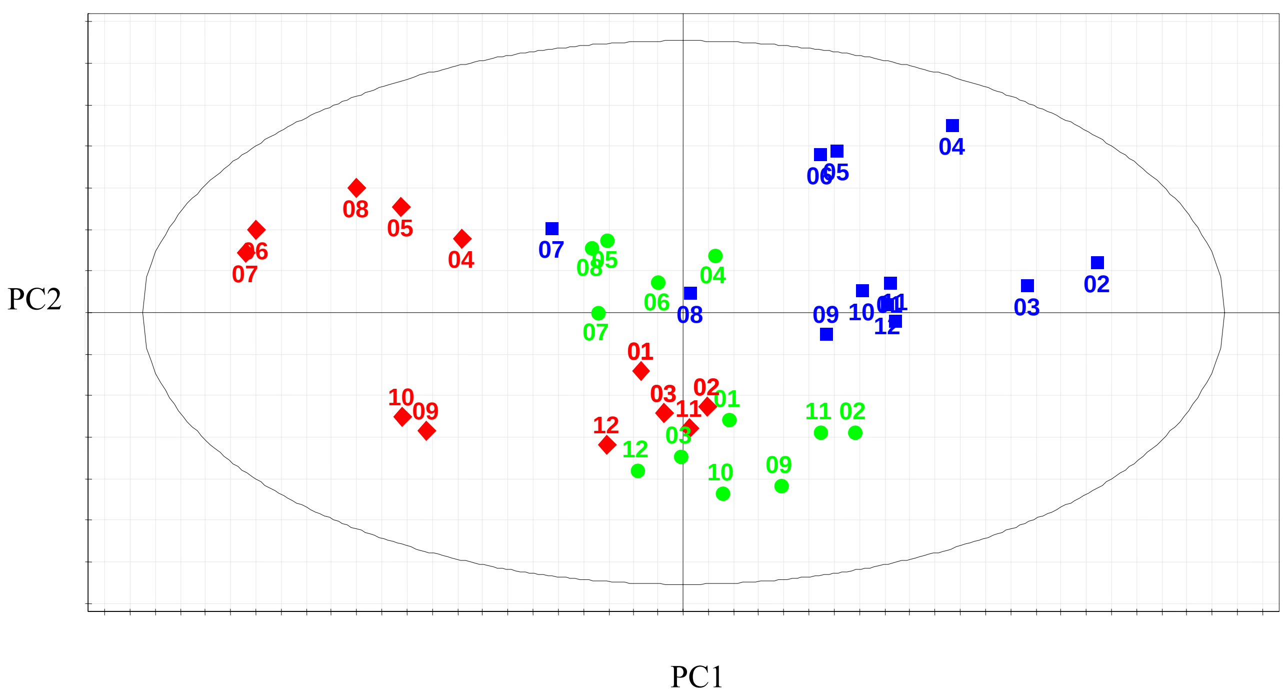
a. Loading plot for the different FA in the organic and conventional cheese.

b. Score plot of the cheese obtain from organic milk (♦) and cheese produced in conventional 1 (■) and 2(●) dairies during 12-mo study (Month 3=March 2007 and month 2=February 2008).

a



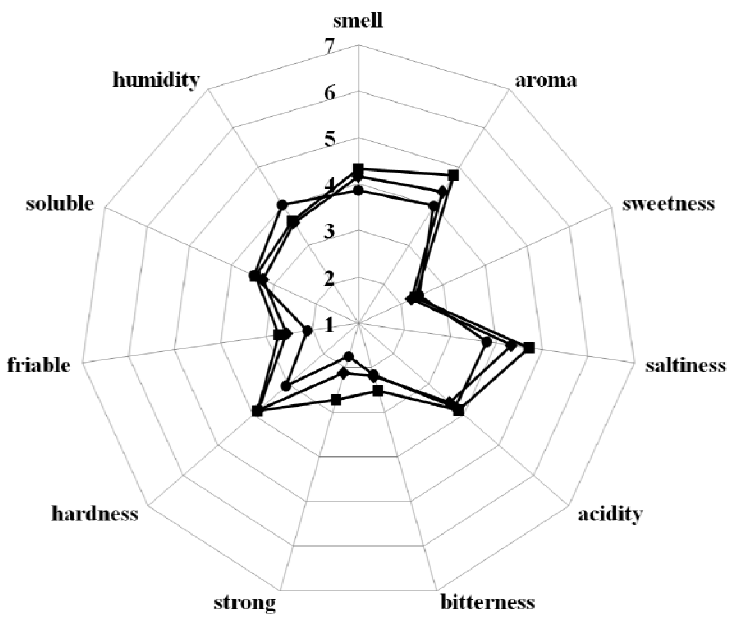
b



3.3.4 Sensory Analysis of Cheeses

The sensory properties of cheeses produced with different production systems were similar. The means of overall attributes are represented in Figure 3.2. The different attributes of organic cheese are intermediate between the two conventional ones not showing a particular sensorial characterization and a preference by panel members.

Figure 3.2. Sensory proprieties of cheese obtain from organic milk (♦) and cheese obtained from conventional 1 (■) and 2(●) dairies. Means of overall attributes (7-point scale).



In conclusion this study confirmed that organic milk has higher vitamin E content and a more elevated concentration of beneficial FA with respect to the conventional milk. The effect of the cheese making process on the FA composition of cheese is very slight and some beneficial FA (e.g. CLA) can increase in cheese in comparison with the original milk after three months of ripening. FA profile can be used to distinguish cheeses obtained from different production systems and, within organic cheeses, those produced in the different seasons of the year. The absence of a significant differentiation in sensorial data does not permit a particular characterization of organic cheese. An additional sensorial analysis with open panel of consumers is desirable in a further trial for a complete sensory evaluation of organic cheese.

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CHAPTER 4

Organic farming of dairy goats in the Veneto Region: feeding management and milk quality

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Abstract

The relationship between the quality of goat milk and the feeding management in organic farms located in the Veneto Region was evaluated. Five organic dairy goat farms with Alpine and Saanen breeds were considered. Samples of bulk milk and feeds were collected monthly and analysed for chemical composition. Milk fatty acids profile was also determined. All data were submitted by ANCOVA analysis using breed (B), time of sampling (ST) and B x ST as fixed effects and dry matter intake (DMI), dietary concentrations of crude protein (CP_c), NDF (NDF_c), starch ($starch_c$), and use of grazing as linear covariates. Milk urea N was positively affected by DMI (r=3.64; $P<0.05$) and negatively by $starch_c$ (r=-5.91; $P<0.05$) and total bacterial count increased significantly ($P<0.05$) with the increase of CP_c and $starch_c$. DMI affected positively the milk fatty acid (FA) profile by increasing of PUFA ($P<0.01$), n-3 ($P<0.001$) and n-6 ($P<0.05$) acids and decreasing of SFA ($P<0.05$) levels in milk. Opposite effects on FA profile were observed by CP_c, NDF_c and $starch_c$. The use of grazing only caused a significant increase ($P<0.05$) in the content of CLA in milk.

4.1 INTRODUCTION

The particularity of dairy goat farming, such as grazing on poor pasture in marginal areas, makes it interesting for the conversion from conventional to organic production. In this species it is quite easy to introduce the organic farming system but the most important problem in dairy goat farms is feeding management, especially during lactation (Moroni *et al.*, 2002; Decandia *et al.*, 2005). The aim of this study was to evaluate the relationship between the composition of goat milk and the feeding management in organic farms located in the Veneto Region.

4.2 MATERIAL AND METHODS

Five organic dairy goat farms (three located in the mountain area and two on plains of the Veneto Region) were considered. Samples of bulk milk were collected from each farm monthly from May (middle lactation) to October (late lactation). In this period the goats are subjected to consistent changes of the diets (i.e. use of pasture) with high consequence on the milk quality. If two breeds (Alpine and Saanen) were present in the same farm, milk samples were collected separately. At milk samplings, all ratios were recorded and samples of the different ingredients of the diets were collected. Milk samples were analysed for chemical composition with an infrared method (Milkoscan 400, Foss Electric) and for urea by enzymatic method. Bacterial count was determined by Bactoscan FC (Foss-Electric). Fat from milk was extracted using Accelerated Solvent Extractor (ASE-Dionex) and fatty acids profile was analysed by gas chromatographic method (Christie, 1982; Chouinard *et al.*, 1999). Some nutritional indexes (IA and IT) of milk were calculated in according to Ulbricht and Southgate (1991). Feed samples were subjected to analyses of chemical composition (AOAC, 2000). All data were analysed by GLM procedure (SAS, 2004). An ANCOVA procedure was performed using breed (B), time of sampling (ST) and B x ST interaction as fixed effects and dry matter intake (DMI), dietary concentrations of crude protein (CP_c), NDF (NDF_c), starch ($starch_c$), and use of grazing (0=no grazing; 1=grazing) as linear covariates. These covariates were selected because of their multicollinearity was lower than 0.70.

4.3 RESULTS AND CONCLUSIONS

The size of 5 selected farms varied from 50 to 150 lactating goats. The main breed reared was Saanen (about 87±22% of the animals). At the beginning of the trial (about 105 DIM), the milk fat and protein percentages were respectively 3.06±0.41 % and 2.75±0.25 %. These values are similar to the data reported by AIA (2007) for the Veneto Region. The breed effect was significant for the milk fat and protein levels (3.40 *vs* 2.96 %; $P<0.001$ and 3.30 *vs* 2.84 %; $P<0.001$ respectively for Alpine and Saanen goats), and total bacterial count (SPC: 3.56 *vs* 4.32; $P<0.001$ in the same order) (Table 4.1). As expected, the sampling time affected several parameters of milk quality due to the advancing of the lactation (from 105 to 255 DIM). No significant interactions were observed between breed and time of sampling.

Table 4.1. ANOVA of the fixed effects considered in the statistical model

		Means	DS	F value of fixed effects			Root MSE
				Breed (B)	Sampling time (ST)	B x ST interaction	
Milk fat	%	3.15	0.52	18.97***	2.92*	0.59	0.30
Milk protein	%	3.02	0.41	59.81***	2.17	0.22	0.15
MUN[1]	mg/dL	35.91	5.77	2.87	2.92*	0.71	4.67
SCS[2]		12.83	0.97	2.51	0.77	0.04	0.91
SPC[3]		4.14	0.91	18.07***	4.68**	2.13	0.68
SFA	% FA	72.50	3.32	0.06	11.97***	1.27	2.07
MUFA	"	23.07	2.77	0.28	7.49***	1.22	1.98
PUFA	"	4.21	0.93	1.33	14.54***	0.39	0.46
SFA/UFA[4]		2.71	0.48	0.05	15.21***	2.19	0.28
n-6	% FA	2.80	0.79	2.62	8.87***	0.20	0.45
n-3	"	0.64	0.15	2.92	6.46**	1.30	0.10
n-6/n-3		4.53	1.34	0.41	0.92	0.64	0.72
CLA	% FA	0.72	0.30	4.28	4.30*	0.11	0.16
IA[5]		2.72	0.36	0.95	9.06***	1.37	0.26
IT[5]		2.87	0.31	7.15*	8.32***	0.83	0.22

[1]MUN=Milk urea nitrogen;
[2]SCS = Somatic cell score, SCS= 3 + log2(SCC/100,000);
[3]SPC=natural log of bacterial count ;
[4]UFA=MUFA+PUFA;
[5]IA= Index of Atherogenicity; IT= Index of Thrombogenicity (Ulbricht and Southgate, 1991). *=P<0.05;**=P<0.01;***=P<0.001

The milk fat and protein were unaffected by DMI, composition of the diets or pasture, probably due to the high variability of this parameters observed in this experiment (Table 4.2). Milk urea nitrogen (MUN) was positively affected by DMI (r=3.64; *P*<0.05) and negatively by dietary starch$_c$ (r=-5.91; *P*<0.01). The increase of DMI positively affected the milk fatty acid profile. In fact with the rise of DMI, PUFA (*P*<0.01), n-3 (*P*<0.001) and n-6 (*P*<0.05) acids increased and the level of SFA decreased (*P*<0.05). Opposite effects on FA profile were observed by dietary CP, NDF and starch concentration. The influence of pasture on the chemical composition of goat milk was in general very low but in grazing animals it caused a significant increased (*P*<0.05) in the content of CLA in milk in according to literature (Chilliard *et al.*, 2002). The improvement of the thrombogenic index was only due by the DMI (r=-2.09; *P*<0.05).

Table 4.2. Estimated regression coefficients of dietary factors affecting chemical composition and fatty acid profile

Item		DMI, kg /d	CP_c,%	NDF_c,%	$Starch_c$, %	Grazing
Milk fat	%	-1.63	0.25	0.02	0.01	0.01
Milk protein	%	-0.07	-0.02	-0.02	-0.11	-0.09
MUN[1]	mg/dL	3.64*	-4.22	-1.04	-5.91*	-4.51
SCS[2]		0.68	-0.19	0.02	-0.11	0.45
SPC[3]		-3.33	0.84*	0.16*	0.86**	0.34
SFA	% FA	-15.60*	3.03*	0.47*	2.62*	0.46
MUFA	“	10.67	-2.27	-0.32	-1.56	-0.11
PUFA	“	4.67**	-0.68*	-0.14*	-1.01***	-0.31
SFA/UFA[4]		-1.52	0.31	0.05	0.29*	0.06
n-6	% FA	0.36*	-0.51*	-0.12*	-0.85***	-0.44
n-3	“	0.95**	-0.18**	-0.04***	-0.11**	-0.11
n-6/n-3		-1.90	0.57	0.09	-0.54	0.34
CLA	% FA	0.03	0.03	0.03	-0.04	0.26*
IA[5]		-1.48	0.28	0.04	0.32**	0.22
IT[5]		-2.09*	0.38**	0.07**	0.36***	0.22

[1]MUN=Milk urea nitrogen;
[2]SCS = Somatic cell score, SCS= 3 + log2(SCC/100,000);
[3]SPC=natural log of bacterial count;
[4]UFA=MUFA+PUFA;
[5]IA= Index of Atherogenicity; IT= Index of Thrombogenicity (Ulbricht and Southgate, 1991). *=P<0.05;**=P<0.01;***=P<0.001

In conclusion, the quality of goats organic milk was affected by breed and sampling time, in according to the results of conventional farming. In addition, the quality of organic milk, and in particular FA profile, was affected by intake and dietary composition. The pasture only improved the content of CLA.

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CHAPTER 5

Meat quality of calves obtained from organic and conventional farming

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Abstract

The aim of this study was to compare meat quality of organically and conventionally raised Simmental calves. Fifteen organic and fourteen conventional carcasses were considered, 8th rib and *longissimus thoracis* were sampled on each carcass. Different tissues percentage of 8th rib were evaluated and meat colour, chemical and fatty acids composition of *longissimus thoracis* were analysed. Fat percentage of 8th rib of organic calves was lower (P<0.01) than conventional ones. Cooking weight losses were lower (P<0.001) in organic meat compared to the conventional ones and red index was higher in organic calves due to the high content of eminic iron (P<0.001). Ether extract (P<0.001) and cholesterol content (P<0.05) was lower in organic meat with respect to conventional one. Positive values, from a nutritional point of view, were found in organic veal about n3 fatty acids, n6/n3 ratio and CLA content.

5.1 INTRODUCTION

Dairy calves obtained from organic farming could be a resource for the production system of organic beef. However only a little part of the calves born on the organic dairy farms are slaughtered and commercialised as organic products (Nielsen *et al.*, 2002). Meat characteristics of calves produced by organic system are almost unknown and in literature there are few studies about the comparison between organic and conventional meat (Woodward *et al.*, 1999). This experiment was carried out to compare meat quality of organically and conventionally raised Simmental calves.

5.2 MATERIAL AND METHODS

Fifteen carcasses of organic calves (144.8 ± 18.6 kg) and fourteen carcasses of conventional calves (155.4 ± 26.6 kg) were considered. The average age at slaughtering was 6 months and all calves belonged to Simmental breed. Organic calves were reared at the pasture and were subjected to natural suckling. The conventional calves received milk replacers and roughage sources according to EU rule (97/2/EC). At slaughtering the 8th rib from the right side of each carcass was removed and immediately vacuum-packed. After 7 days of ageing at 4°C the samples were separated into muscle, bone and intramuscular fat and fresh samples of *Longissimus thoracis* was used for the determination of pH and colour (Minolta CM500 Spectrophotometer) (ASPA, 1996) while on the freeze-dried samples the chemical composition was determined (AOAC, 2000). Cholesterol and eminic-iron contents were detected according to Casiraghi *et al.* (1994) and Hornsey (1956) respectively. Cooking losses and Warner-Bratzler shear force (kg/cm^2) were estimated (ASPA, 1996). Fatty acids were analysed by GC analysis after lipid extraction (ASE® instrument, Dionex) and trans methylation (Christie, 1982). The effect of production system (organic vs conventional) was statistically evaluated by ANOVA (SAS, 2004).

5.3 RESULTS AND CONCLUSIONS

Fat percentage of 8th rib of organic calves (Table 5.1) was lower ($P<0.01$) than conventional ones. Less state of fattening of organic carcasses was found in literature (Russo *et al.*, 2005). The lack of difference in percentage of bone observed indicate no different skeletal development in organic calves.

Table 5.1. Different tissues percentages of 8th rib of organic and conventional calves

Item	ORG	CON	P-value	SEM[1]
Lean, %	69.00	64.08	*	1.38
Fat, %	2.90	7.36	**	0.90
Bone, %	28.10	28.56	ns	1.59

[1]Standard error of the mean.

Cooking losses (Table 5.2) were significantly lower in organic meat compared to the conventional ones ($P<0.001$) while tenderness did not differ between the two groups. Values of lightness and hue were lower in organic meat compared to the conventional one. Higher redness of organic meat, due to the high content of haeminic iron ($P<0.001$), was probably due to grazing activity of organic animals. Ether extract content of *Longissimus thoracis* of organic calves was lower than those of conventional ones ($P<0.001$). The amount of cholesterol was low in organic calves ($P<0.05$) also respect to the standard value reported for veal by IEO (2008).

Table 5.2. Meat quality traits of *Longissimus thoracis*

Item	ORG	CON	P-value	SEM[1]
Cooking losses, %	26.17	31.59	***	0.80
Shear force, kg/cm	2.94	2.73	ns	0.80
Meat colour				
L* lightness	32.56	43.09	***	0.99
a* redness	9.05	4.73	***	0.72
b* yellowness	9.80	11.68	*	0.49
H* hue	47.07	69.88	***	2.37
Chemical composition				
Dry matter	24.27	24.70	ns	0.26
Ether extract	0.76	1.31	***	0.10
Crude protein	22.29	21.91	ns	0.24
Ash	1.11	1.08	ns	0.01
Cholesterol, mg/100g	53.95	58.52	*	1.29
Haeminic iron, mg/kg	47.53	26.07	***	1.78

[1]Standard error of the mean.

About intramuscular fatty acids (FA) composition (Table 3.3) the SFA and PUFA contents were higher in organic meat in comparison with conventional one. From the nutritional point of view positive values were observed in organic meat about n-3 FA and n6/n3 ratio. In addition, CLA content was very high in organic meat and similar (French *et al.*, 2000) or higher (Thomas *et al.*, 2008) respect to the results obtained for meat from grazing cattle.

Table 3.3 Fatty acids composition of *Longissimus thoracis* (% of total FA)

Item	ORG	CON	P-value	SEM[1]
SFA	48.45	42.21	**	1.35
MUFA	29.38	39.13	***	1.02
PUFA	21.93	18.58	***	1.95
SFA/MUFA+PUFA	0.96	0.73	**	0.05
n-3	5.64	2.35	***	0.46
n-6	15.14	15.44	ns	0.56
n-6/n-3	2.66	6.77	***	0.23
CLA	1.08	0.31	***	0.13

[1]Standard error of the mean.

In conclusion, lower fat percentage of carcasses and lower ether extract of meat, higher content of eminic iron, low cholesterol content and FA suggest a better nutritional profile of meat obtained from organic farming. Further researches are needed to confirm our findings.

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CHAPTER 6

Conclusions

The results of this PhD thesis have given interesting information on the possibility to obtain high quality animal products from organic mountain farming.

Many problems related to organic farming management are caused by complex unclear legislation, an in many cases concession of derogations caused by difficulty of interpretation. The new community legislation, in force since 2009 (Reg. 834/2007) should bring clear elements to the operators of the organic livestock farming sector.

From this study on the quality of milk from organic and conventional farms in mountain areas the milk was found to be substantially similar for chemical composition and technological properties despite two production systems were used. The fatty acid profile, instead was viewed favourably from a nutritional point of view for milk obtained form organic farming. Because the fatty acid profile improved during the summer months for milks produced with both organic farming (all are grazing cows) and conventional farming methods (1/3 of farms allow cows to graze), further research is required to determine which limits used in organic farming influence the fatty acid profile.

Based on the trial carried out on cheese made from organic and conventional milk the differences in fatty acid profiles were confirmed, once again in favour of organic cheeses. It is possible to use some of the fatty acid profile parameters (saturated, mono-unsaturated, poly-unsaturated fatty acids, and ratio for some fatty acids of nutritional interest), to distinguish cheese based on the production system used and period of production. Special interest is paid for poly-unsaturated fatty acids, n3 and CLA fatty acids, which are found in cheeses produced in summer from organic milk.

Organic cheese is more yellow and brighter in colour than conventional cheese because it is richer in α-tocopherols. From the sensory analysis no distinctive characteristics resulted for organic cheeses, so it is not possible to distinguish them from conventional ones through taste trials. However, this type of cheese has a commercial value compared to other similar products on the market.

The investigation carried out on organic dairy goat farms in the Veneto region has shown great variability in feed management in farms. Regarding the fatty acid profile for goat milk, the study has revealed better results when grazing was possible; particularly high concentrations of CLA were found in farms where grazing was allowed in the summertime.

Use of pastures was considered a method that, besides reducing production costs also highly improves the qualitative properties of milk.

Finally, organic calf farming results in leaner animals, with a lower cholesterol content, compared to conventionally farmed calves. The quantity of haeminic iron in organic meat almost doubles that found in conventional meat, which causes organic meat to be darker. This aspect is viewed negatively form a commercial point of view: darker meat is not appreciated by consumers who expect it to be slightly pink in colour ("white meat"). Promoting nutritional properties of organic meat in the future must be actively supported by information for the consumer.

Overall, with this thesis it was possible to obtain valid scientific results and also interesting practical considerations, which allowed organic farmers to be involved in experimental trials that help to better understand product quality and improve farm management skills. Farmers, therefore, had an additional instrument to improve and add value to organic products: informative material. Organic-farmed mountain livestock could be exemplified as the method to use for increase the value of some productions and sustainable farming.

CHAPTER 7

Implications

My Ph.D. was supported and funded by Veneto Agricoltura (Regional Agency for Agriculture, Forestry and Agri-food Sectors) with the allocation of Ph.D. grant from title: “Organic animal production systems and quality of products”. The main project involved my collaboration was called “Biobos” about quality and nutritional characteristics of dairy and beef production from organic and conventional systems in the mountain area (Regional Committee Resolution No 897 published on 27/12/2006, within the framework of the 32/1999 Regional Law). The objective of this project, other than the draft of scientific articles included in this Ph.D. thesis, was the publication of promotional material (**Appendix 1**) and organization of several meetings, for specialist and non specialist public, about the results of the project.

I also collaborated on regional plan for improvement and development of organic agriculture, called “Biodemo”, and in particular in the sector about organic farming of dairy goat. During the project several meetings and one training course were made and in addition some datasheet were drafted for the farmers involved in the project.

Outside my Ph.D. theme I collaborated on the interregional plan of rural development “R_INNOVA_PRO_VE” about research and innovation supported by Vegetable Protein Plan (499/1999 Regional Law). In particular I followed the experimental trial on the effect of low antinutritional factors raw full-fat soybean on beef cattle feeding and I drafted a scientific article submitted to the Journal of Animal Science (**Appendix 2**) soon. In addition promotional material, aimed at the farmer, was published as technical brochure (**Appendix 3**).

APPENDIX 1

La qualità del latte biologico da allevamenti di montagna

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CANSIGLIO

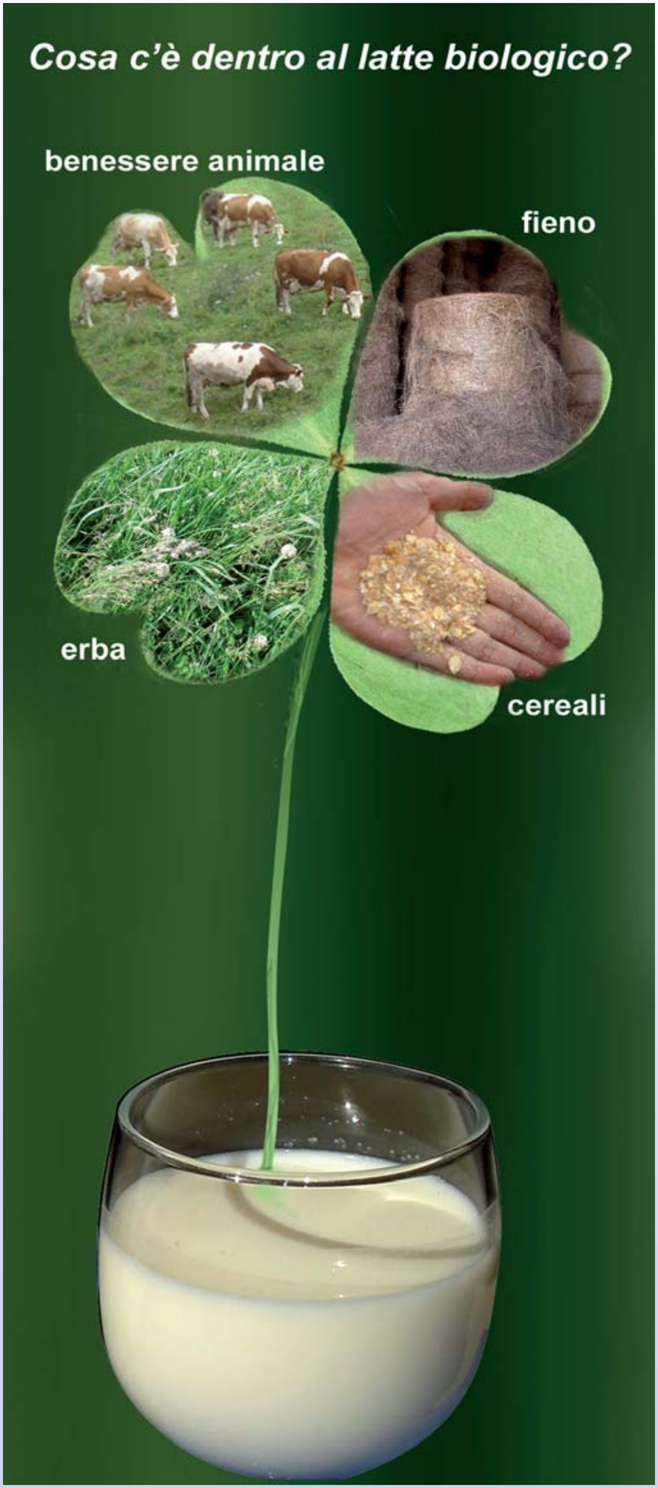
La qualità del latte biologico da allevamenti di montagna

L'allevamento delle bovine da latte secondo metodo biologico segue le indicazioni definite nella normativa comunitaria (Reg. CE 2092/91, Reg. CE 1804/99, Reg. CE 834/07, Reg CE 899/08) integrata da successivi Decreti del Ministero delle politiche agricole, alimentari e forestali (MiPAAF). Il rispetto da parte dell'azienda e del centro di confezionamento del latte delle indicazioni normative è costantemente verificato sia dagli ***Organismi di Controllo*** sul metodo di produzione biologico, riconosciuti dal MiPAAF, sia dai locali organi ufficiali di controllo per gli aspetti igienico-sanitari.
Il latte biologico è quindi un alimento che rispetta tutti gli standard qualitativi previsti dalle normative specifiche di prodotto, oltre ad offrire una garanzia sul metodo di produzione, e sulla tracciabilità "*dalla stalla al bicchiere*".

Cosa prevede il metodo di produzione biologico?

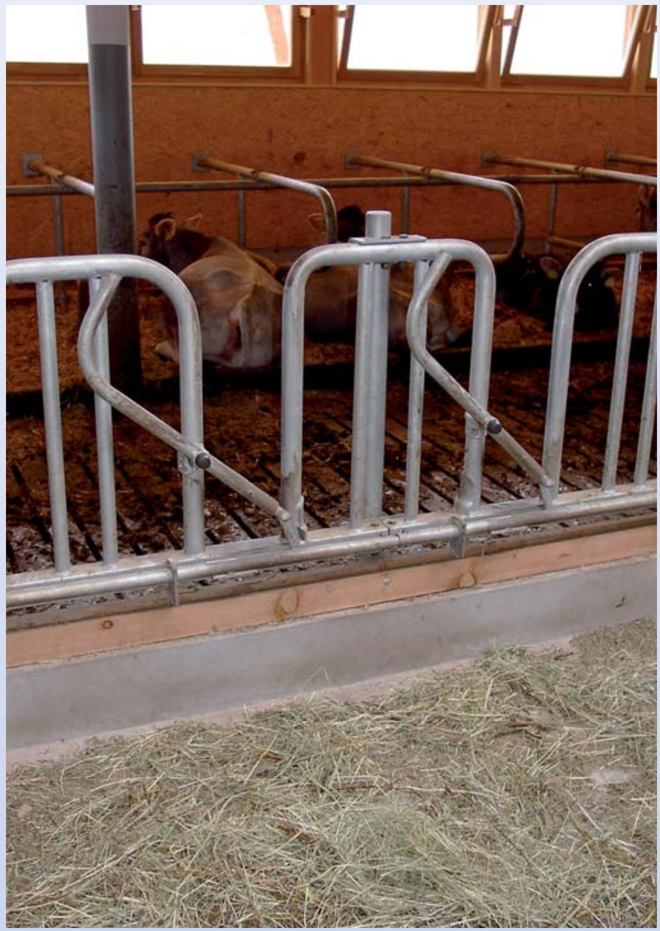
Le aziende agricole-zootecniche devono in primo luogo preferire ***le razze bovine*** rustiche che ben si adattano all'ambiente di allevamento, mostrando una buona resistenza alle comuni patologie. Nell'allevamento biologico in area montana vengono spesso preferite le razze a duplice attitudine (latte e carne) e/o tipiche dell'area (razze autoctone).

Uno degli aspetti caratterizzanti l'allevamento biologico riguarda l'***alimentazione*** delle bovine. Le prescrizioni e i limiti stabiliti dalla normativa sono numerosi e mirano ad avere un ***sistema di produzione sostenibile*** in equilibrio con le produzioni vegetali dell'azienda (foraggi e cereali) e con l'ambiente. Infatti, le produzioni vegetali biologiche sono ottenute senza l'utilizzo di concimi chimici, diserbanti o altri pesticidi di sintesi chimica.
L'alimentazione delle bovine per la produzione di latte biologico deve essere incentrata su un largo utilizzo di foraggi (affienati, verdi o insilati) e un limitato utilizzo di concentrati (mangimi, cereali, semi di leguminose, ecc.). Gli animali inoltre devono avere libero ac-

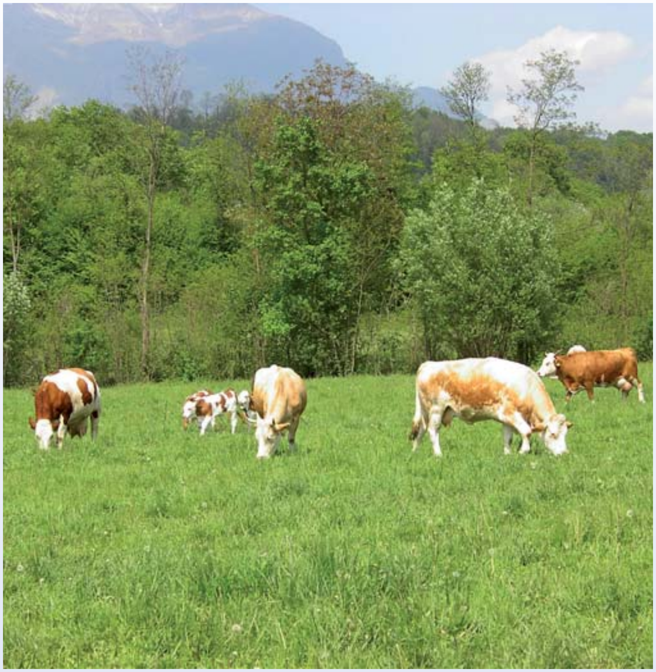


cesso al pascolo, quando le condizioni pedoclimatiche lo permettono; questo consente di migliorare lo stato sanitario e di benessere complessivo degli animali e, in alcuni casi, anche la qualità del latte. Nelle aziende di fondovalle e di montagna il pascolamento viene normalmente praticato per 3-4 mesi, in funzione dell'altitudine.

Nell'alimentazione inoltre non possono essere utilizzati gli alimenti che abbiano subito un trattamento con sostanze chimiche (come la farina di estrazione di soia, di girasole, ecc.) o derivati da piante e altri organismi geneticamente modificati (OGM); inoltre è vietato l'uso di vitamine o altri additivi di sintesi chimica.



Stalla libera a cuccette con area di alimentazione



Spesso negli allevamenti biologici di montagna l'utilizzo del pascolo da parte delle bovine è facilitato dalla presenza di ampie aree di prato-pascolo polifita, che presenta un'elevata biodiversità floristica con numerose specie di erbe.
Un rapporto equilibrato tra animali allevati e superficie coltivata e pascolata (n. di capi/ettaro) è uno dei vincoli del metodo biologico per assicurare la sostenibilità ambientale dell'allevamento, evitando la produzione di eccessive quantità di deiezioni di difficile gestione.
Molta attenzione viene rivolta al ***benessere degli animali***. Le bovine in lattazione o asciutta devono essere preferibilmente mantenute libere in gruppo, meglio se con paddock esterno e con una zona di riposo con lettiera. Le piccole stalle che utilizzano ancora la posta fissa, per il periodo invernale, dovranno prevedere un adeguamento delle strutture, e comunque assicurare nel frattempo la possibilità di accesso al pascolo quando possibile.

Le mutilazioni sono vietate e la decornazione consentita solo in casi limitati.

Un ottimale stato di benessere coniugato con la scelta di razze rustiche e ben adattate all'ambiente di allevamento, insieme a una corretta profilassi vaccinale, consentono di prevenire lo sviluppo delle patologie più diffuse nelle bovine da latte ad alta produzione. In caso di patologia accertata, il veterinario è chiamato a intervenire prioritariamente con rimedi a basso impatto come i ***prodotti omeopatici o fitoterapici,*** e ricorrendo solo successivamente, o nei casi più gravi, ai comuni farmaci allopatici (antibiotici, antinfiammatori, ecc.).
In tutti i casi di utilizzo di farmaci veterinari convenzionali il tempo di sospensione del trattamento prima dell'utilizzo dei prodotti (latte o carne) è comunque doppio rispetto a quello previsto nelle indicazioni di legge per il farmaco utilizzato.

Allevamenti biologici e convenzionali

Per verificare l'effetto sulla qualità del latte dei diversi metodi di produzione, "biologico" e "convenzionale", è stato scelto un campione di allevamenti della montagna bellunese con caratteristiche simili per dimensione, razza di animali allevati e alcuni aspetti gestionali.
Infatti alcuni parametri qualitativi del latte, come contenuto di proteine e grassi, sono influenzati dalla razza della bovina oltre che dall'alimentazione.
Gli allevamenti convenzionali scelti per il confronto, non rappresentano comunque la realtà produttiva della montagna veneta, dove insistono molti allevamenti da latte più intensivi e con una produzione certamente più elevata rispetto a quella riscontrata nel campione.
Negli allevamenti interessati all'indagine la consistenza media dei capi allevati è risultata variabile, con piccole stalle di 10-15 capi fino a mandrie di 60-70 bovine. Le razze principalmente allevate sono la Pezzata Rossa Italiana e la Bruna, anche se si possono incontrare, in numero più limitato, capi di Frisona, oltre a un piccolo numero di meticce.
Quasi tutte le aziende utilizzano, anche se in modo diversificato, il pascolo nel periodo primaverile-estivo.
Nelle aziende biologiche l'utilizzo di foraggio, in modo

particolare fieno di prato polifita e insilato d'erba, è maggiore rispetto alle aziende convenzionali; queste ultime, invece, includono nella razione alimentare una maggiore quantità di concentrati (mangimi).

Caratteristiche degli allevamenti

	"biologici" N. 10	"convenzionali" N. 6
dimensione media mandria (n. capi)	30	30
razze allevate (%)		
• Pezzata Rossa	50	60
• Bruna	40	30
• Frisona	5	5
• altre razze e incroci	5	5
produzione media (kg latte/capo/giorno)	22	16
durata del pascolo (giorni/anno)	120-150*	0-60
rapporto foraggio/concentrati nella razione		
• invernale	60:40	60:40
• estiva	80:20	60:40
% vacche con più di 3 lattazioni	31	28
durata media della lattazione (giorni)	314	274
media inseminazioni IA/concepimento	1.6	1.6

**indicativamente da metà maggio a metà ottobre*

La qualità del latte biologico

L'indagine ha previsto campionamenti mensili in tutti gli allevamenti selezionati per oltre un anno, in modo da valutare tutte le variazioni stagionali dovute al cambio di alimentazione e di gestione degli animali.

Caratteristiche qualitative del latte crudo

	latte "biologico"	latte "convenzionale"
Proteine totali (%)	3,34	3,39
di cui caseina (%)	*2,50*	*2,54*
Grasso (%)	3,74	3,81
Lattosio (%)	4,86	4,89
Urea (mg/dL)	26,22	20,69
Cellule somatiche (cell. x 1000/ml)	256	315
Carica batterica totale (micr x 1000/ml)	199	103

Il latte prodotto presso le aziende biologiche non presenta differenze per quanto riguarda la composizione chimica di base rispetto al latte prodotto in allevamenti convenzionali di montagna con simili condizioni pedoclimatiche.
Il ***contenuto di proteine*** è risultato mediamente di 3,34% e quello di grasso superiore al 3,70%, in entrambi i tipi di latte. Questo è un dato positivo per il latte biologico, in quanto i vincoli normativi nell'utilizzo di alcuni alimenti per l'integrazione proteica della razione (farine di estrazione di soia, ecc.) non sembrano condizionare negativamente la qualità nutrizionale del prodotto.

I ***parametri igienico-sanitari*** (contenuto di cellule somatiche e carica microbica totale) hanno evidenziato valori nella norma, con un contenuto di cellule somati-

che di molto inferiore al limite di legge, che per il latte crudo, destinato alla produzione alimentare, è pari a 400.000 cellule/ml.

Molto interessante è risultato invece il ***profilo acidico del grasso del latte***, ovvero l'analisi dei singoli componenti (acidi grassi) che, come è noto, hanno un diverso valore nutrizionale per l'uomo.
Da questa analisi è emerso che il latte prodotto con metodo biologico è tendenzialmente ***meno ricco di acidi grassi saturi (SFA)***, ritenuti negativi dal punto di vista nutrizionale in quanto tendono a depositarsi con più facilità sulle pareti delle arterie, oltre a favorire l'aumento del livello di colesterolo nel sangue.
Il latte biologico risulta invece ***più ricco di acidi grassi mono (MUFA) e polinsaturi (PUFA)*** con un valore dietetico nutrizionale superiore. In particolare, alcuni di questi ultimi sono considerati "**essenziali**" per l'organismo umano e hanno effetti benefici sulla riduzione della colesterolemia e sul sistema cardio-circolatorio più in generale.

Il profilo acidico del grasso del latte

	latte "biologico"	latte "convenzionale"
Acidi grassi saturi (SFA)	67,5	70,7
Acidi grassi monoinsaturi (MUFA)	27,9[a]	25,0[b]
Acidi grassi polinsaturi (PUFA)	4,7[a]	4,0[b]
Rapporto saturi/insaturi	2,1[a]	2,5[b]
Indice aterogenico	2,4[a]	3,0[b]
Indice trombogenico	3,1	3,7

a, b: le differenze tra i valori sono statisticamente significative

Questa caratteristica viene evidenziata dal miglior ***indice aterogenico***, parametro che esprime l'effetto negativo dei grassi sul sistema circolatorio, del latte biologico rispetto al convenzionale, che prende in considerazione il rapporto fra alcuni acidi grassi ad azione negativa con quelli invece benefici per l'organismo umano.

Contenuto in vitamine (µg/ml) del latte

	latte "biologico"	latte "convenzionale"
Vitamina A	0,70	0,83
Vitamina E	0,82	0,53

Mediamente il contenuto di vitamina A e di vitamina E nel latte biologico è risultato molto simile a quello convenzionale; alcune differenze sono state comunque rilevate soprattutto nel periodo estivo durante il quale il latte biologico è risultato ***più ricco di vitamina E***.

La vitamina E è un'importantissima sostanza antiossidante (α-*tocoferolo*) in grado di svolgere una funzione essenziale nella protezione delle membrane cellulari, contro gli attacchi dei radicali liberi presenti nell'organismo.

Il maggior contenuto di vitamina E di origine naturale, e non di sintesi chimica, nel latte biologico va collegato all'alimentazione estiva ricca di foraggio verde.

Riguardo al contenuto in ***elementi minerali*** non sono state rilevate differenze significative fra il latte ottenuto con metodo biologico e quello convenzionale. In entrambi i casi i valori sono in linea con quanto riportato dall'INRAN (*Istituto Nazionale di Ricerca per gli Alimenti e la Nutrizione*) nelle tabelle di composizione chimica degli alimenti.

Contenuto di elementi minerali (mg/100g) del latte

	latte "biologico"	latte "convenzionale"
Calcio	118	117
Fosforo	85	86
Potassio	148	148
Magnesio	10	10
Sodio	38	36

I risultati del presente progetto hanno evidenziato che l'allevamento biologico, se praticato con competenza nell'ambiente sensibile e vulnerabile della montagna, permette di valorizzare la ricchezza dei foraggi e dei pascoli del territorio e ottenere latte e prodotti derivati di ottima qualità nutrizionale.

Progetto "Qualità e caratteristiche nutrizionali dei prodotti ottenuti da allevamento biologico dei bovini in area montana" – BIOBOS

Attività realizzata con il finanziamento della Regione del Veneto, L.R. n. 32/99 art. 4, Direzione Agroambiente e Servizi per l'Agricoltura Servizio Ricerca, Sperimentazione e Diversificazione Aziendale

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APPENDIX 2

Effects of low antinutritional factors raw full-fat soybean on beef cattle feeding. Performance and carcass quality

Study results published on Agriculture 13:2007 (1) 180-183

and presented at 16th International Symposium Animal Science Days, Strunjan, Slovenija, 17-19 September 2008.

INTRODUCTION

Soybean seeds and derivates are valuable protein-rich feed ingredients used in beef cattle feeding (Jordan et al., 2006). Similar to other oleaginous seeds, soybean also contains some nutritionally harmful compounds known as anti-nutritional factors (i.e. soybean Kunitz and Bowman-Birk trypsin inhibitors) (Laskowski and Kato, 1980). The high levels of trypsin inhibitors in seeds cause poor digestion of dietary proteins by inhibiting the pancreatic enzymes (Liener, 1994). Cultivars with low anti-nutritional content factors could be used in animal feeding, without requesting physical processes of inactivation such as the toasting (Friedman et al., 1991). As know, toasting treatment can affect adversely the quality of some proteins. In addition, because raw soybean seeds are toasted frequently in large plants (vegetable oil producers) the feed traceability could be critical in the GMO free chain (i.e. organic animal production). The number of farm home-made protein feed production is increasing in Italy, especially in respect to the organic production systems. For these purposes, the availability of low anti-nutritional factors soybean is becoming a nutritional benefit and a operative simplification. The aim of this study was to evaluate the effects of different soybean sources on the infra-vitam performance, carcass and meat quality of fattening beef cattle.

MATERIALS AND METHODS

All procedures involving animals during the study were approved by the "Ethical Committee for the care and use of experimental animals" of the University of Padova (CEASA – Comitato Etico di Ateneo per la Sperimentazione Animale).

Animals and Diets

The trial was carried out in the experimental farm of the University of Padova. Fifty-six Limousin beef cattle (initial BW 287 ± 17 kg) were used. The calves arrived at the experimental station in October 2006 and all animals were vaccinated against bovine viral diarrhoea (BVD), bovine rhinotracheitis (IBR) virus, parainfluenza (PI_3) virus, bovine respiratory syncytial virus (BRSV) and treated with Ivermectin against parasites and with Tulathromycin as antibiotic against respiratory diseases.According to BW the animals were housed in 14 fully slatted floor pens with four animals each and divided in 4 experimental groups: **SBM** (soybean meal; 12 animals); **LAFS** (raw full-fat soybean low in antinutritional factors, cultivar "Hilario", SIS, Bologna, I; 16 animals), **NTS** (non toasted full-fat soybean, mix of different cultivars; 16 animals) and **TS** (toasted full-fat soybean, mix of different cultivars; 12 animals). Each group was fed a transition diet during the adaptation period (first 25 days after the arrival) to avoid stress problems. Subsequently, the animals were fed with four experimental diets formulated to be isoenergetic and to meet the nutritional requirements of the cattle according to INRA (1988) and NRC (2000). The animals received a basal total mixed ration (TMR) once daily by mixer wagon (8.00 a.m.). Immediately after the TMR distribution, the soybean sources were added to the diets by top-dressing in order to reach the same amount of additional protein (473 g/d). In order to maintain the same amount of lipids content in the diets, 234 g of calcium soap of palm fat were added to SBM diet. Since 117 days of trial (at about 440 kg of BW of animals) 1 kg of corn meal were added in all experimental diets to carry on with the finishing diet (Table 1).

Table 1. Ingredients and chemical composition of the diets

Diets	Adaptation (0-25 d)	Fattening (25-117 d)	Finishing (117-222 d)
Ingredients, % DM			
Corn silage	—	46.5	42.9
Corn meal	35.8	19.1	25.3
Dry sugar beet pulp	24.0	10.0	9.2
Wheat bran	12.0	8.3	7.7
Permanent meadow hay	12.0	2.5	2.3
Vitamin-mineral premix[1]	3.0	2.1	1.9
Soybean sources[2]	13.2	11.5[3]	10.7[3]
Chemical composition, % DM			
CP	14.5	14.0	13.6
Lipids	2.9	5.8	5.7
NDF	32.6	30.8	28.7
Starch	28.3	30.0	34.4
Meat Forage Units	0.98	0.98	1.01

[1]Containing per kg: 2040 mg of vitamin PP, 500 mg of vitamin E (α-tocopherol 91%), 0.4 mg of vitamin B12, 240,000 IU of vitamin A, 15,000 IU of vitamin D3, 1680 mg of zinc, 11200 mg of sulphur, 650 mg of manganese, 100 mg of copper, 20 mg of iodine, 12 mg of cobalt, 3 mg of selenium,

[2]Soybean sources: SBM = soybean meal; NTS = non toasted full-fat soybean; LAFS = raw full-fat soybean low in antinutritional factors; TS = toasted full-fat soybean.

[3]For SBM experimental group added of calcium soap of palm fat containing per kg DM: 50 mg of ethoxyquin, 100 mg of butylhydroxytoluene, 30 mg of manganese, 10 mg of nicotinic acid.

Measurements, Controls and Analysis

The first 25 days of the trial were considered as adaptation period, while during the following days, experimental controls were performed. All animals were individually weighed monthly and daily gains were calculated. Animal health was detected daily throughout the trial. During the second part of the trial one bull of the LAFS group was removed because of tail necrosis and shank oedema. All the corresponding data were excluded from the statistical analysis. In order to evaluate DM daily intake, the amounts of TMR distributed were recorder and orts were weighted daily. Samples of each ingredient of the diets were analyzed for their proximate composition (AOAC, 2000) and their NDF content (Van Soest et al., 1991). Starch content was determined by liquid chromatography (AOAC, 2000). The analysis of urease activity on soybean sources were assessed by NGD method (NGD, 1976) and the values are reported as pH variation. The trypsin inhibitors (TI) activity was determined according to spectrophotometers procedure suggested by Krishnan (2001).

All animals were weighed and slaughtered after 222 d of trial. Hot carcasses were individually weighed and evaluate according to EU classification grid for muscularity and fatness (Anonymous, 1991). Carcasses pH was also determined at 3, 8 and 24 hours after slaughtered.

Half-carcasses were selected for individual samples of *Longissimus thoracis and lomborum* muscle between 8th thoracic and 1st lumbar vertebra. At five random locations of the sample joint pH was determined using a Crison pH-meter with a penetrating electrode. Meat colour was measured by Minolta CM500 Spectrophotometer (Illuminant D 65) after 1 hour exposition of samples to air at 4°C (ASPA, 1996) and colour data were expressed according to the International Commision on Illumination (CIE) L* (brightness; 0=black, 100=white), a* (redness/greenness; positive values = red, negative values = green), and b* (yellowness/blueness; positive values= yellow, negative values =green) colour values. All values for L*, a*, and b* were determined by calculating the average of 3 readings obtained from randomly selected locations on the meat through the polyvinyl chloride film. Cooking losses were measured using 2 cm thick steaks sealed in a plastic bag and heated in a water bath at 75°C for 55 min (ASPA, 1996). The tenderness was measured as the shear force (kg/cm^2) using Warner Bratzler shear device and a texture expert software, on 1-inchdiameter cylinders cooked meat. Meat chemical analysis (DM, lipids, CP and ash) was determined following official method (AOAC, 2000).

Fatty acid (FA) methyl esters were prepared and analyzed by gas chromatography (8000 Series Top Thermo Quest Italia, Milano – capillar coloumn Omegavax 250, 30m x 0.25 mm i.d) using the method of Christie (1982) and Chouinard (1999). Results were trasformed to present each individual fatty acid as a percentage of the total FA in the meat fat sample. In addition atherogenic and thrombogenic indexes were calculated using Ulbricht and Southgate (1991) equation.

Statistical Analysis

Data were analysed by GLM procedure of SAS (SAS, 2002) with the following model:

$$y_{ijk} = \mu + D_i + P_j(D_i) + \varepsilon_{ijk}$$

where y_{ijk} = the experimental observation; μ = overall mean; D_i =effect of the experimental diet (i=1,…4); $P_j(D_i)$ = effect of pen within experimental diet; ε_{ijk} = residual error. The effect of experimental diet was tested using an error line based on pen effect. Data of BW were covaried with the corresponding value at the beginning of the trial.

For pen data of DMI, feed efficiency, carcass and meat quality the GLM approach including experimental diets effects (one-way ANOVA) was used.

Following orthogonal contrast were run to test the significance of the experimental diet effects: 1) SBM diet vs the average of diets containing full-fat soybean (SBM vs. LAFS+NTS+TS), 2) NTS diet vs the average of other diets with raw full-fat soybean (NTS vs LAFS +TS), 3) LAFS vs TS diet.

The level of significance was set to $P<0.05$, $P<0.01$, and $P<0.001$.

RESULTS AND DISCUSSION

Evaluation of Diets and Soybean Sources

The chemical composition and nutritional values of four experimental diets are given in Table 1. During the fattening period the level of CP, NDF and starch of the experimental diets were 14.0, 30.8 and 30% DM respectively. The four diets were isoenergetic (0.98 Meat Forage Units per kg DM). During the finishing period the level of CP and NDF decrease and starch and net energy increased due to the raise of corn in the TMR. The chemical characteristics of soybean sources included in the diets during the experimental period are reported in Table 2. The chemical composition of feeds was similar to that reported in literature (Frieddman et al., 1991). The urease activity can be related to the different heat treatments of the soybean sources and higher in raw and non toasted soybean in comparison with soybean meal and toasted soybean. TI activities are high in raw full-fat soybean seeds but the value is quite half in raw full soybean low in antinutritional factors (27 mg/g). The toasted soybean seed showed some residual TI activity.

Table 2. Chemical characteristics of soybean sources used in the experiment

Item	Soybean meal	Non toasted full-fat soybean	Raw full-fat soybean low in antinutritional factors	Toasted full-fat soybean
Dry matter,%	88.4	88.2	90.1	89.3
CP, %DM	47.6	39.7	37.5	38.7
Lipids, %DM	2.4	20.2	18.0	20.7
NDF, %DM	12.6	13.3	16.9	15.5
Ash, %DM	6.9	5.1	5.3	5.4
Urease activity, ΔpH	0.18	2.35	2.27	0.21
TI activity[1], mg inhibit trypsin/g protein	—	68	27	12

[1] TI= trypsin inhibitors activity

In vivo Performance

During the trial no serious pathological events or metabolic disorders were observed on the animals of the different experimental groups. Similar results were obtained in a previous experiment by Snidaro et al. (2005) using Simmental beef cattle.

Effects of dietary treatments on BW are shown in Table 3. No differences were detected among experimental groups, neither at the end of fattening period (117 d) nor at the end of the trial (after 222 d). The initial BW was affect significantly (*P*<0.001) the weight of the animal at the different period of the trial. The final BW was on average 587.1±47.8 kg in according to the standard slaughter weight for Limousin animals in Italy, as reported by Cozzi and Gottardo (2005).

During the first 25 days of the experiment, the average daily gains were, as expected, different among experimental groups (data not shown) due to the adaptation phase of the animals.

Table 3. Body weight of the experimental groups during the trial

	Experimental diet[1]				b[2]	RSME[3]
Item	**SBM**	**NTS**	**LAFS**	**TS**		
BW, kg						
At arrival, 0 d	288.4	290.4	284.6	282.7	-	17.0
At beginning, after 25 d	329.3	329.9	336.3	318.6	0.74	10.3
After 117 d	445.5	448.9	457.1	431.5	1.23	29.7
Before slaughter, 222 d	597.7	578.3	603.8	565.6	1.52	47.8

[1]Experimental diet: SBM = soybean meal; NTS = non toasted full-fat soybean; LAFS = raw full-fat soybean low in antinutritional factors; TS = toasted full-fat soybean.
[2]Regression coefficient (P<0.001)
[3]Root of mean square error

During the fattening period (from 25 to 117 d) no statistically significant differences of ADG were observed among experimental groups (Table 4) while during fattening period the SBM experimental group showed a higher ADG respect to the groups fed with raw full-fat soybean (1.45 vs 1.30 kg/d; *P*=0.04). Considering the whole trial LAFS group reported a higher ADG respect to TS group (1.35 vs 1.24 kg/d; *P*=0.06). This is very close to those reported by other authors for Limousin young bulls fattened in intensive farms in the Veneto region (Cozzi et al, 2005) but lower in comparison with the data obtained from a survey about growth performance of different breeds in the Veneto region (Sturaro et al., 2005). In addition Snidaro et al. (2005) found lower ADG (1.26 vs 1.24 kg/d) in Simmental beef cattle fed a basal diet supplemented with soybean meal in comparison with raw full-fat soybean low in antinutritional factors. The differences of ADG between non toasted full-fat soybean diet and row full-fat soybean diets are not significant considering the different periods or whole trial.The effect of experimental diets on voluntary DMI during trial was limited and not significant (Table 4). During the experiment DMI increase from about 9.1 of the fattening period to 10.1 kg/d of the final one. DM intake values of this experiment are in harmony with the results obtained by Cozzi et al. (2005) on Limousin bulls during the finishing period in intensive rearing system. Feed efficiency was very similar among the experimental diets and this value was on average 0.134 kg/kg DM. Albro et al. (1993) found a greater gain efficiency in steers fed raw soybeans in comparison with steers fed extruded soybeans.

Table 4. Weight gain, DMI and feed efficienty of the experimental group during the trial

	Experimental diet[1]				RSME[2]	Contrast *P*-value[3]		
Item	**SBM**	**LAFS**	**NTS**	**TS**		1	2	3
ADG, kg/d								
Fattening period, 25 to 117 d	1.27	1.30	1.31	1.20	0.29	0.98	0.38	0.27
Finishing period, 117 to 222 d	1.45	1.39	1.24	1.27	0.31	0.04	0.19	0.13
Whole trial, 25 to 222 d	1.37	1.35	1.27	1.24	0.24	0.10	0.67	0.06
DMI, kg /d								
Fattening period, 25 to 117 d	9.28	9.14	9.32	8.88	0.68	0.91	0.52	0.15
Finishing period,117 to 222 d	10.48	9.94	10.26	9.71	0.75	0.51	0.19	0.19
Whole trial, 25 to 222 d	9.76	9.46	9.70	9.21	0.51	0.75	0.41	0.24
Feed efficency, kg/kg DM								
Fattening period, 25 to 117 d	0.134	0.129	0.138	0.138	0.022	0.30	0.64	0.97
Finishing period,117 to 222 d	0.136	0.132	0.135	0.137	0.020	0.64	0.93	0.88
Whole trial, 25 to 222 d	0.134	0.130	0.137	0.137	0.006	0.11	0.48	0.95

[1]Experimental diet: SBM = soybean meal; NTS = non toasted full-fat soybean; LAFS = raw full-fat soybean low in antinutritional factors; TS = toasted full-fat soybean.[2]Root of mean square error
[3]1 = SBM vs LAFS+NTS+TS; 2 = NTS vs LAFS+TS; 3 = LAFS vs TS.

Carcass Performance Traits

No significant differences for carcass traits (Table 5) were observed among the four experimental groups except of the weight of the hot carcass of LAFS and TS groups (385 and 358 kg respectively; *P*=0.02). Dressing percentages were similar among groups with an average value of 63.4%, in according to the results obtained by Bilik et al. (2009) in Limousin bulls feeding with maize silage at different intensive levels of feeding. The score of muscularity and fatness resulted very similar among experimental groups. The average value of muscularity score was 3.23, corresponding to the letter U+ of the SEUROP classification systems (U: very good). The fattening score was on average 2.56, intermediate between scarce (score=2) and significant (score=3) carcass fat thickness. The values of pH carry out at 3, 8 and 24 hours after slaughtering reflect the normal fall in pH value during the post-mortem period. The trend is similar among the four experimental groups.

Table 5. Carcass traits of the experimental groups during the trial.

	Experimental diet[1]					Contrast *P*-value[3]		
Item	**SBM**	**NTS**	**LAFS**	**TS**	RSME[2]	1	2	3
Hot carcass weight, kg	383.8	369.9	385.5	357.6	31.2	0.21	0.86	0.02
Hot dressing percentage,%	63.9	63.4	64.1	63.9	2.4	0.83	0.41	0.85
SEUROP classification:								
Muscularity [4]	3.33	3.12	3.27	3.25	0.43	0.40	0.34	0.92
Fatness [5]	2.33	2.81	2.53	2.50	0.48	0.08	0.06	0.86
pH after slaughtering:								
after 3 hours	6.45	6.41	6.44	6.42	0.14	0.59	0.58	0.78
after 8 hours	5.51	5.62	5.54	5.49	0.20	0.46	0.13	0.49
after 24 hours [6]	5.49	5.30	5.37	5.31	0.25	0.18	0.75	0.65

[1]Experimental diet: SBM = soybean meal; NTS = non toasted full-fat soybean; LAFS = raw full-fat soybean low in antinutritional factors; TS = toasted full-fat soybean.[2]Root of mean square error
[3]1 = SBM vs LAFS+NTS+TS; 2 = NTS vs LAFS+TS; 3 = LAFS vs TS.
[4]SEUROP scoring system for muscularity (S+ = 6.33, … , P- = 0.66)
[5] SEUROP scoring system for fatness (1= very lean, … , 5= very fat).
[6]Data relate to 28 animals

Meat Quality

Meat quality characteristics estimated in the bulls fed with difference sources of soybean are reported in Table 6. Physical properties and pH value of meat were similar among groups. Warner-Bratzler shear force (WBSF) was on average 2.67 kg with no effect due to the experimental diet. This value is widely less than values of WBSF for tenderness acceptability ranged from 4.31 to 5.99 kg (Destefanis et al., 2008). Additionally, there were no differences in proximate composition of the reference muscle.

The colour of the meat was affected by the treatments. The lightness value (L*) was lower and therefore, better in LAFS and TS groups than in NTS group (38.4 vs 39.2; $P<0.01$). In addition, the redness and yellowness indexes of LAFS group were significantly lower ($P<0.05$) than those of TS group.

Table 6. *Longissimus thoracis and lomborum* muscle (MTLT) characteristics of the experimental groups during the trial.

Item	Experimental diet[1]				RSME[2]	Contrast *P*-value[3]		
	SBM	**NTS**	**LAFS**	**TS**		1	2	3
pH	5.43	5.44	5.44	5.43	0.03	0.91	0.97	0.69
Cooking losses, %	28.54	26.09	27.54	26.63	5.24	0.42	0.77	0.89
WBSF[4], kg	2.82	2.95	2.66	2.72	0.78	0.75	0.11	0.75
Proximate composition, %								
Moisture	75.47	75.28	75.49	74.84	1.21	0.42	0.73	0.11
CP	22.06	22.36	22.22	22.50	0.42	0.14	0.99	0.23
Lipids	1.33	1.25	1.04	1.51	0.51	0.79	0.91	0.09
Ash	1.13	1.11	1.25	1.15	0.13	0.54	0.17	0.18
Instrumental colour analysis[5]								
L*	39.01	39.18	38.60	38.25	2.62	0.21	<0.01	0.27
a*	10.76	10.92	10.41	11.68	1.56	0.12	0.42	<0.001
b*	12.89	13.04	12.63	13.12	1.77	0.85	0.37	0.02

[1]Experimental diet: SBM = soybean meal; NTS = non toasted full-fat soybean; LAFS = raw full-fat soybean low in antinutritional factors; TS = toasted full-fat soybean.
[2]Root of mean square error
[3]1 = SBM vs LAFS+NTS+TS; 2 = NTS vs LAFS+TS; 3 = LAFS vs TS.
[4]Warner-Bratzler shear force
[5]International Commission on Illumination L*= lightness; a*= redness; b*= yellowness values

In table 7 the fatty acid profile of reference muscle is reported. The percentage of saturated FA (SFA) of the LAFS group was lower than that of TS group (46.6 vs 49.1% of total FA; $P<0.05$) and this difference is due to the different levels of myristic and, in particular, palmitic acids. The use of soybean meal (SBM) in the diet significantly increase ($P<0.01$) the contents of C 16:0 and C 18:0 in comparison with inclusion of full fat soybean. The content of MUFA and in particular of oleic acid was similar in all diets. On the contrary PUFA were higher in LAFS diet respect to TS diet ($P=0.06$). The values of n-3 and n-6 fatty acids of LAFS were higher than those of TS ($P=0.07$).

Table 7. Fatty acid profile (% of total FA) of the *longissimus thoracis and lomborum* muscle of the experimental groups during the trial.

	Experimental diet[1]					Contrast *P*-value[3]		
Item	**SBM**	**NTS**	**LAFS**	**TS**	RSME[2]	1	2	3
SFA (total)	48.53	47.68	46.64	49.05	2.18	0.47	0.86	0.05
Myristic (14:0)	2.72	2.58	2.30	2.84	0.39	0.44	0.93	0.02
Palmitic (16:0)	27.70	24.21	23.12	24.91	1.31	<0.001	0.73	0.02
Stearic (18:0)	15.89	18.40	18.98	18.87	1.72	<0.01	0.50	0.90
MUFA (total)	38.03	37.03	34.45	36.17	3.02	0.14	0.21	0.30
Oleic (18:1)	34.22	33.72	31.41	32.94	2.63	0.22	0.20	0.29
PUFA (total)	12.21	13.42	17.35	13.43	3.69	0.15	0.24	0.06
Linoleic (18:2)	8.72	9.88	12.82	9.86	2.71	0.10	0.23	0.06
Linolenic (18:3)	0.34	0.50	0.64	0.46	0.09	<0.001	0.24	<0.01
PUFA *n-3*	0.86	0.99	1.38	0.98	0.39	0.16	0.29	0.07
PUFA *n-6*	10.87	12.02	15.58	12.03	3.48	0.16	0.26	0.07
PUFA *n-6/n-3*	12.73	12.28	11.88	12.42	2.36	0.62	0.90	0.67
CLA	0.43	0.37	0.36	0.39	0.09	0.20	0.81	0.56
IA[4]	0.77	0.69	0.63	0.73	0.07	0.01	0.89	0.01
IT[5]	1.71	1.63	1.53	1.72	0.16	0.30	0.90	0.05

[1]Experimental diet: SBM = soybean meal; NTS = non toasted full-fat soybean; LAFS = raw full-fat soybean low in antinutritional factors; TS = toasted full-fat soybean.
[2]Root of mean square error
[3]1 = SBM vs LAFS+NTS+TS; 2 = NTS vs LAFS+TS; 3 = LAFS vs TS.
[4] IA= Index of Atherogenicity;[5] IT= Index of Thrombogenicity (Ulbricht and Southgate, 1991)

Levels of conjugated linoleic acid (CLA) were similar among experimental groups and on average 0.39% of total FA. Both indexes of Atherogenicity and Thrombogenicity were significantly lower (*P*=0.01 and *P*=0.05 respectively)in LAFS than TS diet, indicating a better fatty acids profile in meat obtained from cattle fed with raw full-fat soybean low in antinutritional factors.

In conclusion raw full-fat soybean low in antinutritional factors can be used in diets for feedlot cattle fed corn silage based diets without negative effects on animal health and infra-vitam performances of beef cattle during the fattening period. Neither the carcass traits nor the chemical and physical properties of meat (except for colour) were affected significantly by the inclusion of this raw soybean. Fatty acids profile of meat results better in LAFS group, with a lower content of saturated FA and an higher content of polyunsaturated FA, in particular linolenic acid.

Thus, the raw full-fat soybean low in antinutritional factors can be included in the diet for fattening cattle, especially in organic or OGM-free chains, as well as an alternative to soybean meal (not allowed in organic production systems) also as alternative to toasted full-fat soybean (without problems of traceability during the toasting process).

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APPENDIX 3

Utilizzo della soia integrale cruda a basso contenuto di fattori antinutrizionali nell'alimentazione di suini e bovini

Dipartimento di Scienze Animali
Università degli Studi di Padova

Utilizzo della soia integrale cruda a basso contenuto di fattori antinutrizionali nell'alimentazione di suini e bovini

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Introduzione

Nell'integrazione proteica delle razioni per ruminanti e monogastrici si è da sempre fatto largo uso della *farina di estrazione di soia*, quale prodotto secondario ottenuto dall'industria di estrazione e lavorazione degli oli di semi. Infatti, la qualità delle proteine della soia e il loro valore biologico, ne hanno consigliato un vasto utilizzo nell'alimentazione animale, soprattutto nell'allevamento intensivo dei monogastrici (polli, ovaiole, suini, ecc.).
Il fabbisogno nazionale e comunitario di soia per alimentazione animale è largamente soddisfatto dalle importazioni da Paesi non UE, come USA, Argentina e Brasile. Negli ultimi anni, in questi Paesi l'utilizzo di varietà di soia geneticamente modificate (OGM) è diventato maggioritario rispetto a quelle non GM, tanto da rendere quasi impossibile e molto costoso, ottenere partite di semi di soia o di farina di estrazione, con un contenuto OGM inferiore ai limiti imposti da alcune certificazioni volontarie di prodotto, come nel caso di produzioni zootecniche biologiche o di altre filiere NO OGM (contenuto di OGM < 0,9 %).
Attualmente la produzione nazionale di soia dovrebbe garantire senza particolari problemi, almeno per la fase di coltivazione, raccolta e stoccaggio, un prodotto non GM attraverso apposite filiere certificate; più difficile risulta invece la tracciabilità completa di questi prodotti quando vengono avviati alla lavorazione (tostatura, macinatura, estrazione dell'olio) in quanto potenzialmente a rischio "contaminazione" con prodotti OGM importati.
I costi della tracciabilità e il rischio di contaminazione nelle filiere di soia (semi o derivati) non OGM sono molto elevati, e stimati in circa il 10-15% del prezzo di mercato per il prodotto convenzionale o destinato all'allevamento biologico. Questi problemi non sembrano attualmente risolvibili per l'industria mangimistica o per gli allevamenti, se non attraverso filiere controllate e stabilimenti dedicati.
Un'alternativa alle "classiche" filiere della soia per le aziende zootecniche, in grado di superare gli attuali vincoli di lavorazione extraziendale dei semi (tostatura, decorticazione, macinazione, estrazione dell'olio), può essere rappresentata dall'utilizzo aziendale di *soia cruda integrale*, autoprodotta o acquistata sulla base di specifici contratti di coltivazione.
Questa possibile soluzione è però sempre stata considerata non percorribile per la presenza nei semi crudi di soia di fattori antinutrizionali (ANF), responsabili di interferenze con i processi di digestione e di utilizzazione dei nutrienti contenuti nella razione alimentare, rendendo sconsigliabile l'utilizzo diretto della soia in forma cruda, nel razionamento degli animali domestici.
Gli ANF presenti nel seme di soia sono numerosi (fattori antitripsinici, lectine, proteine antigene, alcaloidi); tra i più attivi vanno ricordati gli inibitori tripsinici (IT) Kunitz e Bowman-Birk responsabili dell'inattivazione degli enzimi digestivi tripsina e chimosina e della conseguente riduzione della digeribilità ga-

stro-intestinale delle proteine alimentari. Il contenuto di questi fattori nelle varietà di soia commercializzate in Italia può superare i 24 mg/g di sostanza secca, che rappresenta circa il 6% delle proteine totali presenti nel seme.
Gli animali più sensibili all'azione di questi fattori sono i monogastrici e, più in generale, i soggetti giovani nei quali l'apparato digerente è incompleto come struttura e capacità digestiva. Ne consegue che a seguito dell'assunzione di soia cruda una maggiore quantità di proteina indigerita giunge negli ultimi tratti del tubo digerente, dove può dare origine a fermentazioni non desiderabili (es. sviluppo di ceppi batterici patogeni come E. Coli emolitico) con produzione di molecole tossiche (amine-biogene, istamine, ammoniaca, ecc.).
Per tali ragioni, prima di essere impiegato nella formulazione delle razioni alimentari, il seme di soia deve subire un trattamento di tipo chimico e/o fisico (tostatura, estrusione, micronizzazione) al fine di denaturare e quindi inattivare le proteine ad azione antinutrizionale, ottenendo un consistente aumento del valore nutrizionale dell'alimento.
I fattori antinutrizionali si caratterizzano per una differente sensibilità a tali trattamenti. I fattori della famiglia dei Kunitz (peso molecolare 20.000 Da) sembrano essere particolarmente sensibili all'azione del calore e possono essere inattivati anche dai succhi gastrici intestinali; ne consegue, quindi, che l'azione di questi fattori antinutrizionali dipende anche dalla forma fisica (semi interi, spezzati, farina) con la quale gli alimenti sono somministrati agli animali. I fattori di Bowman-Birk (peso molecolare compreso tra 6 e 12.000 Da) sembrano, invece, essere più resistenti alla denaturazione termica per la particolare configurazione strutturale conferita da numerosi ponti disolfuro. Per questi motivi in relazione all'intensità del trattamento termico

i semi di soia conservano una certa attività antitripsinica che, espressa in *mg di tripsina inibita per g di proteina alimentare*, è compresa tra 50-85 nella soia cruda e a valori prossimi a 5 nel seme tostato di buona qualità.

Questi valori se espressi in termini di attività antiureasica sono rispettivamente pari a 2 e 0,2 ΔpH. Valori inferiori di attività antitripsinica (e di attività ureasica) implicano un trattamento termico molto intenso che può portare alla formazione di composti di Maillard (legami stabili tra proteine e zuccheri) con conseguente riduzione della digeribilità e del valore biologico delle proteine alimentari.

Il processo di tostatura dei semi deve quindi considerare numerose variabili (temperatura, umidità, pressione, tempo, granulometria e forma fisica dell'alimento, flusso del calore, volumi trattati, ecc.) per ottenere un prodotto finito di elevata qualità.

Oltre ai sopraindicati problemi tecnici, l'esigenza di effettuare trattamenti fisici sulla soia non consente agli allevatori un consumo diretto dei raccolti aziendali che devono essere preventivamente consegnati presso gli appositi stabilimenti di lavorazione. Ciò può rappresentare un vincolo all'utilizzazione di questo prodotto nell'alimentazione degli animali domestici, soprattutto presso gli allevamenti che adottano il protocollo di produzione biologico.

Per superare tali problemi si stanno diffondendo a livello pratico la coltivazione, lo stoccaggio e l'impiego diretto nel razionamento di nuove varietà di soia selezionate per il ridotto contenuto di alcuni fattori antinutrizionali. Mediante le tradizionali tecniche di miglioramento genetico sono state ottenute delle varietà di soia che presentano un livello di questi fattori pari a 7-10 mg/g, valore che, secondo alcune evidenze sperimentali, non determinerebbe un peggioramento delle performance di crescita e degli indici di conversione di suini pesanti in accrescimento. Secondo altri autori, varietà di soia con un'attività antitripsinica di 9,9 mg/g sarebbero responsabili di un'evidente riduzione della digeribilità apparente delle proteine della dieta e degli accrescimenti giornalieri di suini di 30 kg di peso vivo. Scarse sono invece le informazioni relative agli effetti dei fattori antinutrizionali della soia sui ruminanti, sui parametri metabolici e sullo stato di salute dell'animale.

Inoltre, la possibilità di utilizzare queste varietà di soia in forma cruda nel razionamento degli animali domestici, oltre a consentire una maggiore autonomia dell'azienda rispetto al mercato, può permettere una riduzione dei costi di alimentazione grazie ai minori oneri di trasformazione della materia prima.

Il primo obiettivo di questa sperimentazione è stato quello di valutare le caratteristiche agronomiche delle cultivar di soia, dichiarate dal costitutore a basso contenuto di fattori antinutrizionali, nelle normali condizioni di produzione.

Successivamente si è valutata la composizione chimica e l'attività degli inibitori tripsinici (IT) di alcune varietà di soia ampiamente utilizzate nel mercato nazionale e di quelle a basso contenuto di antinutrizionali.

In seguito sono state effettuate due prove in campo per comparare l'impiego di soia convenzionale e soia a basso contenuto di fattori antinutrizionali, sia nel razionamento di monogastrici che di ruminanti.

Una prima prova è stata realizzata utilizzando suini in fase di accrescimento e di finissaggio, allevati secondo il metodo di produzione biologico. Sono stati testati mangimi contenenti soia integrale trattata termicamente (SIT) e soia integrale caratterizzata da un basso contenuto di fattori antinutrizionali non trattata termicamente (SIBA). Sono stati quindi rilevati gli effetti delle diete sperimentali sulle prestazioni di accrescimento, sugli indici di conversione alimentare, su alcuni parametri metabolici e immunitari, e infine, su alcune caratteristiche qualitative delle carcasse in fase di macellazione.

Una seconda prova è stata messa a punto durante il ciclo finale d'ingrasso di vitelloni di razza Limousine. Sono stati testati l'utilizzo di una varietà di soia integrale a basso contenuto di fattori antinutrizionali (SIBA), in sostituzione alla farina di estrazione di soia (FES) comunemente usata negli allevamenti come fonte proteica, e alla soia integrale tostata (SIT) e non tostata (SINT) di produzione nazionale. La prova in vivo è stata effettuata con l'intento di valutare l'effetto dei fattori antinutrizionali sull'allevamento del vitellone e, più precisamente, verificare eventuali influenze sulle prestazioni infra-vitam (ingestione alimentare, capacità di crescita, conversione alimentare) e post-mortem (resa al macello, caratteristiche qualitative della carcassa e della carne dopo la macellazione). Inoltre sono state valutate le condizioni di salute degli animali attraverso il rilievo giornaliero dello stato sanitario, nonché mediante la valutazione dei principali parametri metabolici (sangue e liquido ruminale).

Aspetti agronomici delle cultivar di soia a basso contenuto di fattori antinutrizionali

Il lavoro di miglioramento genetico, che ha consentito di ottenere le prime varietà a basso contenuto di fattori antinutrizionali, è stato inizialmente sviluppato dall'ERSA del Friuli Venezia Giulia, su materiali di origine americana. Le varietà commercializzate in questi anni, riprodotte e selezionate dalla SIS - Società Italiana Sementi di San Lazzaro di Savena (BO), appartengono a diversi gruppi di maturazione (tab. 1) e sono commercializzate con i nomi: Aires, Ascasubi, Colorado, Hilario e Pedro.

Nella tabella 2 le 5 varietà succitate sono state suddivise in gruppi di maturazione e confrontate con altre varietà che presentano un normale contenuto di fattori antinutrizionali valutate nei tre anni di coltivazione su parcella, secondo il protocollo di coltivazione condiviso tra i partner di progetto. Nella tabella è indicato, per ogni varietà e per ciascun anno, l'indice produttivo, calcolato ponendo uguale a 100 la media produttiva complessiva dei due campi presso i quali sono state realizzate le prove sperimentali (Ceregnano, RO e Mogliano V.to, TV).

Come è possibile desumere anche dal grafico 1, le varietà a basso contenuto di fattori antinutrizionali risultano tendenzialmente meno produttive delle varietà "normali". Il vantaggio offerto da questi materiali, (utilizzo della soia cruda, una volta pulita ed essiccata) risulterebbe quindi limitato da una minore potenzialità produttiva, più evidente nei gruppi di maturazione meno precoci. Tra le cinque varietà, tuttavia, è possibile segnalare positivamente ***Ascasubi*** e soprattutto ***Colorado***, che nella media dei 3 anni di prove riescono a realizzare *performance* produttive superiori ad alcune varietà normali abbastanza diffuse (Colorado sarà commercializzata dalla campagna 2009).

Le varietà a basso contenuto di fattori antinutrizionali, sebbene mostrino una minore capacità produttiva, in diversi casi hanno evidenziato un tendenziale maggiore contenuto percentuale di proteina (+ 1,5-2 %). Questo interessante aspetto emerge più chiaramente nel confronto tra coltivazione "convenzionale" e "biologica", con un maggior contenuto di proteina della soia biologica. Tutto questo è comunque da verificare su un maggiore numero di situazioni pedoclimatiche e di coltivazione (disponibilità idrica, fertilità residua, ecc.).

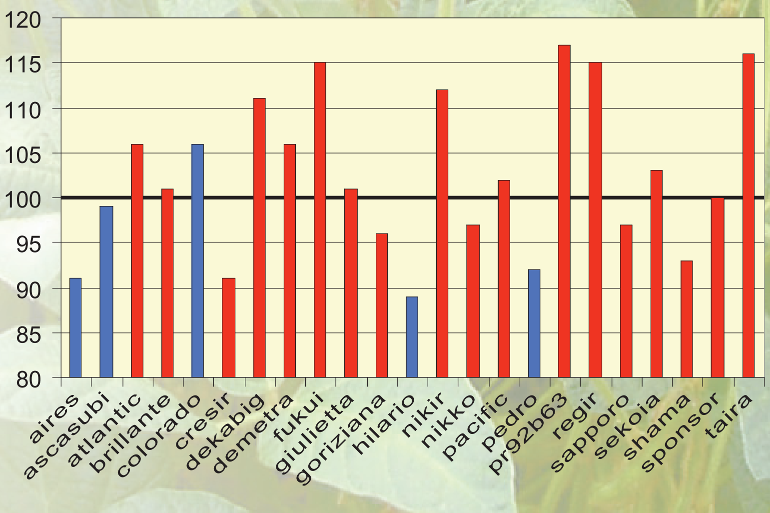
Tabella 1 - Caratteristiche delle varietà a basso contenuto di fattori antinutrizionali.

VARIETÀ	Gruppo	Colore		Altezza				Peso 1000 semi			
		fiore	peluria	2006	2007	2008	MEDIA	2006	2007	2008	MEDIA
AIRES	0+	viola	marrone	64	74	75	71	191	196	219	202
ASCASUBI	1	viola	marrone	77	87	90	85	191	195	205	197
COLORADO	1+	viola	marrone	62	80	81	74	172	190	211	191
HILARIO	1	viola	argentea	69	77	82	76	189	190	196	192
PEDRO	1-	viola	marrone	80	81	85	82	171	191	190	184

Tabella 2 – Risultati produttivi 2006-2008.

Gruppo	VARIETÀ	Indice produttivo			
		2006	2007	2008	MEDIA
0+	AIRES-SIS	89	86	99	91
	CRESIR - PIONEER	85	89	99	91
1-	PEDRO - SIS	101	86	88	92
	NIKKO - DEKALB	88	104	99	97
1	ASCASUBI-SIS	100	99	98	99
	HILARIO-SIS	89	94	84	89
	ATLANTIC - RENK VENTUROLI	95	113	110	106
	BRILLANTE - NK	103	104	95	101
	DEMETRA - NK	111	106	101	106
	FUKUI - DEKALB	112	119	113	115
	GIULIETTA - GOLDEN HARVEST	110	95	97	101
	GORIZIANA - VENETO SEMENTI	105	89	93	96
	NIKIR - PIONEER	111	115	110	112
	PACIFIC - SIS	103	110	94	102
	REGIR - PIONEER	113	116	117	115
	SAPPORO - DEKALB	111	89	92	97
	SEKOIA - SEMFOR	105	99	105	103
	SHAMA - GOLDEN HARVEST	86	103	90	93
	SPONSOR - SEMFOR	100	105	95	100
1+	COLORADO -SIS	104	112	103	106
	DEKABIG - DEKALB	109	121	104	111
	PR92B63 - PIONEER	124	122	106	117
	TAIRA - DEKALB	113	121	113	116

Grafico 1 – Indici produttivi (media anni 2006-2008).



Caratterizzazione di alcune varietà di soia integrale

Cinque partite di soia di varietà Dekagib, Cresir, Brillante ("convenzionali") e Hilario e Aires (a basso contenuto di fattori antinutrizionali), caratterizzate da differenti classi di maturazione, sono state prodotte in prove parcellari presso l'azienda agricola "L. Toniolo" (Legnaro, Padova), campionate e sottoposte ad analisi chimica. Analogamente, partite di soia di varietà Hilario, prodotte presso l'azienda agricola "Sasse Rami"(Ceregnano, Rovigo) e utilizzate nella formulazione dei mangimi nelle prove sperimentali, sono state caratterizzate dal punto di vista chimico. I campioni di soia integrale sono stati sottoposti a un trattamento termico in autoclave per 20 minuti alla temperatura di 110°C. I campioni di soia trattati e non trattati e i mangimi sperimentali delle due prove (suini e bovini) sono stati analizzati in doppio per determinare la composizione chimica tipo. Il profilo acidico dei lipidi negli alimenti è stato valutato per via gas-cromatografica. L'attività ureasica (indice del grado di tostatura) è stata valutata utilizzando la metodica ufficiale e i valori sono stati espressi come variazione di pH. Il profilo proteico dei campioni di soia è stato caratterizzato per elettroforesi. L'attività degli inibitori tripsinici (IT), presenti nei semi di soia integrale, è stata determinata secondo una procedura spettrofotometrica e i valori sono stati espressi in mg di tripsina inibita per mg di proteina alimentare incubata.

Risultati

In tabella 3 è riportata la composizione chimica dei campioni di soia delle varietà "convenzionali" (Decabig, Cresir, Brillante) e selezionate per un ridotto contenuto di fattori antitripsinici Kuniz (Hilario, Aires). Tutte le varietà presentano una composizione chimica e un profilo acidico della frazione lipidica relativamente omogenei.

L'attività ureasica delle diverse varietà di soia è relativamente omogenea e di poco superiore a 2 ΔpH. A seguito del trattamento termico l'attività ureasica si è ridotta a valori compresi tra 0,1 e 0,2 che sono comunemente considerati indice di un ottimale grado di tostatura dei semi. Valori più elevati indicano la presenza di fattori antinutrizionali ancora attivi, mentre, se inferiori suggeriscono che la matrice alimentare è stata sottoposta ad un trattamento termico eccessivo in grado di compromettere la solubilità delle proteine. Questi aspetti sono particolarmente importanti al fine di massimizzare la disponibilità digestiva degli amminoacidi e in particolare della lisina.

Come atteso, l'attività degli inibitori tripsinici (IT) delle varietà Dekagib, Cresir e Brillante è decisamente superiore a quella delle varietà Hilario e Aires. Una volta sottoposte a trattamento termico, l'attività antitripsinica delle diverse varietà di soia si è sensibilmente ridotta a valori medi pari a 12 mg di tripsina inibita per g di proteina. Nonostante questa tendenza generale, è stata osservata un'ampia variabilità di questo parametro all'interno delle diverse varietà, indice di una non omogenea azione del trattamento termico sulle diverse matrici alimentari. Questi risultati suggeriscono che l'attività ureasica è un indice non sempre adeguato alla valutazione del grado di inattivazione degli IT presenti nei semi di soia.

Tabella 3 - Composizione chimica, attività ureasica ed antitripsinica di alcune partite di soia reperite sul mercato.

	SOIA CONVENZIONALE				
	Dekagib (1+) [1]	**Cresir (0+) [1]**	**Brillante (1) [1]**	**Hilario (1) [1]**	**Aires (0+) [1]**
Composizione chimica					
- Sostanza secca, %	85,6	86,5	86,3	86,3	85,8
- Ceneri, % ss	5,1	5,0	5,0	5,0	5,3
- Proteina grezza, % ss	41,6	40,6	41,7	40,1	40,8
- Estratto etereo, % ss	19,4	20,5	19,4	19,6	19,9
- Fibra grezza, % ss	6,3	7,2	6,3	7,3	6,0
Composizione acidica					
- SFA, % EE	16,9	16,9	16,2	16,9	16,3
- MUFA, % EE	25,3	28,2	28,7	24,6	22,4
- PUFA, % EE	57,8	54,9	55,1	58,6	61,3
- $\sum \omega 3$, % EE	7,0	6,1	6,5	6,7	6,7
- $\sum \omega 6$, % EE	50,7	48,8	48,6	51,9	54,6
Caratterizzazione attività:					
ureasica, Δ pH					
- Soia cruda	2,19	2,10	2,25	2,26	2,12
- Soia tostata	0,13	0,20	0,18	0,15	0,05
antitripsinica, mg tripsina inibita/g proteina					
- Soia cruda	40	63	55	27	20
- Soia tostata	12	18	3	7	12

SFA= acidi grassi saturi; MUFA= acidi grassi monoinsaturi; PUFA= acidi grassi polinsaturi; EE= estratto etereo.

[1] Classe di maturazione

Effetti dell'impiego di soia cruda con un basso contenuto di fattori antinutrizionali nell'alimentazione di suini in accrescimento

La sperimentazione è stata realizzata presso l'Azienda pilota "Sasse Rami" di Veneto Agricoltura (Ceregnano, RO), in un allevamento biologico di suini a ciclo chiuso. Lo svolgimento del test esplorativo si è articolato in due prove: la prima, concernente l'ingrasso, si è svolta nel periodo ottobre 2005 - gennaio 2006; la seconda, comprendente anche la fase di accrescimento, è stata effettuata tra novembre 2006 e maggio 2007.

Disegno sperimentale

PRIMA PROVA > Quarantotto suini ibridi (scrofa PIC x verro Goland), del peso vivo iniziale di circa 80 kg, sono stati stabulati in recinti all'aperto in quattro box di 12 soggetti ciascuno, omogenei per peso vivo iniziale e sesso. I soggetti sono stati alimentati con un mangime normalmente utilizzato in azienda con l'aggiunta di soia integrale: due box ricevevano soia integrale tostata (tesi SIT), mentre gli altri due box ricevevano un'analoga proporzione di soia integrale cruda a basso contenuto di fattori antinutrizionali (tesi SIBA). I suini sono stati allevati per 109 giorni e sono stati macellati ad un peso vivo medio di 180 kg.

SECONDA PROVA > Analogamente alla precedente, in questa prova sono stati utilizzati 48 suini ibridi (scrofa PIC x verro Goland) con un peso vivo iniziale pari a circa 36 kg. Gli animali sono stati stabulati in box multipli su lettiera permanente dotati di paddock esterni e sono stati divisi in quattro gruppi di 12 soggetti, omogenei per peso vivo iniziale e sesso. Due gruppi sono stati alimentati in due fasi consecutive con altrettanti mangimi appositamente formulati e contenenti soia integrale tostata (tesi SIT), mentre gli altri due gruppi sono stati alimentati con analoghi mangimi dove la soia tostata è stata sostituita con soia cruda (tesi SIBA) di varietà Hilario, caratterizzata da un ridotto contenuto di fattori antinutrizionali. In questa prova i suini sono stati allevati per 154 giorni e sono stati macellati al peso vivo medio di circa 170 kg.

Diete sperimentali

La formulazione e la composizione chimica dei mangimi impiegati nelle due prove sono riportate in tabella 4. I mangimi sono stati formulati in modo da risultare isoproteici ed isoenergetici. In fase di formulazione delle diete si è dovuto tener conto dei vincoli inerenti la disponibilità di materie prime biologiche presso il mangimificio.

PRIMA PROVA > Gli animali sono stati alimentati *ad libitum* con il mangime di finissaggio normalmente impiegato in azienda con l'aggiunta del 10% di soia integrale cruda di varietà Hilario a basso contenuto di IT (Tesi SIBA), o un'analoga proporzione di soia integrale tostata convenzionale (Tesi SIT).

SECONDA PROVA > In questo caso sono state previste due fasi alimentari, la prima per il periodo di accrescimento da 30 a 110 kg e la seconda per l'ingrasso da 110 a 180 kg. Nella prima fase i suini sono stati alimentati *ad libitum* con mangimi biologici che contenevano il 20% rispettivamente di soia cruda a basso contenuto di IT (Tesi SIBA), o soia tostata convenzionale (Tesi SIT). Nella seconda fase i suini sono stati razionati all'80% della capacità di ingestione con due mangimi contenenti soia cruda o soia tostata in proporzioni pari al 5% della razione.

Rilievi sperimentali e analisi statistica dei dati

I suini sono stati pesati individualmente per un totale di 3 rilievi nel caso della prima prova (0, 43 e 106 giorni di prova), e 4 rilievi nel caso della seconda prova (0, 37; 67 e 151 giorni di prova). In coincidenza di ogni pesatura, è stata eseguita la misurazione dello spessore del lardo dorsale con ecografo. Al termine delle due prove sono state effettuate le macellazioni di tutti i suini e si è proceduto alla determinazione del peso delle mezzene, dello spessore del lardo dorsale e del peso di fegato, di reni e di pancreas. Infine, dalla coscia sinistra di ogni suino è stato prelevato un campione di grasso di rifilatura, utilizzato per la valutazione della composizione acidica del grasso di copertura.

Tabella 4 - Formulazione dei mangimi sperimentali (%) utilizzati nelle due prove.

	Prova 1		Prova 2			
	Mangime (80-180 kg PV)		Mangime (30-110 kg PV)		Mangime (110-170 kg PV)	
Alimenti	SIT	SIBA	SIT	SIBA	SIT	SIBA
- Cruscami di frumento	40	40	30	30	36	36
- Mais farina	11	11	36	36	30	30
- Orzo farina	25	25	10	10	25	25
- Soia integrale tostata	10	-	20	-	5	-
- Soia integrale cruda	-	10	-	20	-	5
- Erba medica disidratata	5	5	-	-	-	-
- Pisello farina	5	5	-	-	-	-
- Integratore minerale	2,7	2,7	2,5	2,5	2,7	2,7
- Lievito	1,3	1,3	1,5	1,5	1,3	1,3

SIT= soia integrale tostata; SIBA= soia integrale cruda a basso contenuto di fattori antinutrizionali.

RISULTATI

I mangimi sperimentali

In tabella 5, è riportata la composizione chimica dei mangimi impiegati nelle due prove di alimentazione. Nella prima prova, al mangime normalmente impiegato in allevamento, nella fase di finissaggio dei suini, è stata aggiunta una quota di soia pari al 10% della razione giornaliera al fine di verificarne gli effetti sull'ingestione alimentare e sugli accrescimenti giornalieri. Come atteso quindi, il tenore di proteina e di lisina delle due diete è superiore ai fabbisogni nutrizionali previsti per suini in fase di finissaggio. Analogamente, anche il tenore in acido linoleico delle due razioni è risultato nettamente superore al 2%, livello massimo raccomandato per ottenere un grasso di copertura delle cosce di qualità adeguata per la trasformazione. Sorprendentemente, l'attività ureasica è risultata negativa nel caso del mangime SIT mentre prossima a 2 ΔpH nel mangime SIBA. I valori negativi possono essere spiegati dal fatto che la metodica di determinazione dell'attività dell'enzima ureasi è stata messa a punto per l'analisi del seme di soia e, probabilmente, non è adatta a matrici complesse come un mangime composto.

I valori di attività ureasica prossimi a 2 indicano che la soia cruda non ha subito trattamenti termici.

I mangimi della seconda prova sono stati appositamente formulati per coprire i fabbisogni aminoacidici ed energetici di suini in accrescimento (lisina/EM=0,63 g/MJ) e finissaggio (lisina/EM=0,45 g/MJ). Nella prima fase di allevamento i suini sono stati alimentati con mangimi contenenti elevate proporzioni di soia (20% della razione) al fine di verificarne gli effetti sugli accrescimenti ponderali, mentre nella seconda fase gli apporti di soia sono stati ridotti (5% della razione) con l'obiettivo di formulare una razione alimentare con un contenuto di acido linoleico prossimo al 2%, come indicato dai principali disciplinari di produzione del prosciutto crudo ("Parma", "San Daniele", ecc.). In tal modo si è inteso valutare la possibilità di limitare gli effetti negativi derivanti dalle elevate proporzioni di acidi grassi insaturi apportati dalla soia sulla qualità del grasso di copertura delle cosce.

Effetti su alcuni indici produttivi

In tabella 6 sono riportati gli effetti dell'impiego di soia cruda di una varietà con un ridotto contenuto di fattori antinutrizionali o tostata "convenzionale" sugli accrescimenti ponderali e sull'efficienza di conversione alimentare rilevati nella prima prova sperimentale. La sostituzione del 10% di soia tostata (SIT) con un'equivalente quantità di soia cruda (SIBA) non ha evidenziato effetti significativi sul peso a fine ciclo, sugli accrescimenti ponderali giornalieri, sui consumi alimentari e quindi sugli indici di conversione alimentare. Va tuttavia osservato che il ritmo di accrescimento è diminuito oltre le attese, passando da 1,2 kg/giorno nella prima fase a 0,6 kg/giorno nella seconda fase sperimentale, nonostante i suini fossero stati alimentati *ad libitum* per l'intera durata della prova. I consumi alimentari, invece, sono stati relativamente simili nel corso delle due fasi sperimentali, con un indice di conversione alimentare che, di conseguenza, è drasticamente peggiorato nel corso dell'ultimo mese di prova.

Questo evidente peggioramento dell'indice di conversione alimentare che ha caratterizzato tutti i suini in prova, può essere ricondotto all'abbassamento delle temperature ambientali che ha determinato un aumento dei fabbisogni di termoregolazione e la riduzione degli accrescimenti ponderali. Ulteriore conseguenza dell'abbassamento delle temperature è il parziale congelamento del terreno che, provocando notevoli difficoltà di movimento agli animali, ha condizionato il comportamento ali-

Tabella 5 - Composizione chimica, attività ureasica e antitripsinica dei mangimi utilizzati nelle due prove sperimentali.

	Prova 1		Prova 2			
	Mangime (80-180 kg PV)		**Mangime** (30-110 kg PV)		**Mangime** (110-170 kg PV)	
	SIT	SIBA	SIT	SIBA	SIT	SIBA
Composizione chimica						
- Sostanza secca, %	89,4	89,9	88,5	88,5	88,3	88,7
- Proteina grezza, % ss	15,1	15,3	16,1	16,4	12,5	12,5
- Estratto etereo, % ss	4,8	4,9	6,7	7,2	4,0	4,3
- Fibra grezza, % ss	5,6	5,6	4,2	4,2	4,4	4,6
- Ceneri, % ss	7,2	7,1	5,8	5,7	5,7	5,6
- Acido linoleico, % ss	2,5	2,4	3,4	3,4	2,2	2,2
- Lisina, % ss	0,70	0,70	0,80	0,80	0,53	0,53
- EM, Mj/kg ss	11,3	11,3	12,6	12,6	11,7	11,7
Attività:						
- ureasica, Δ pH	-0,45	2,19	0,19	1,83	0,04	0,59
- antitripsinica, mg tripsina inibita/g proteina	8	14	17	26	10	16

SIT= soia integrale tostata; SIBA= soia integrale con un basso contenuto di fattori antinutrizionali.
EM= energia metabolizzabile

mentare e ha determinato un aumento non quantificabile degli sprechi di mangime; aspetto inevitabile nelle descritte condizioni di allevamento. Durante la stagione fredda, in condizioni di stabulazione all'aperto, i piani alimentari prevedono normalmente un aumento del 10% degli apporti di mangime allo scopo di coprire i maggiori fabbisogni energetici degli animali, ma, la modificazione dei fabbisogni nutrizionali, suggerisce l'opportunità di adeguare la formulazione delle diete riducendo il rapporto tra proteina ed energia con conseguenti effetti positivi sui costi alimentari.

Lo spessore del grasso dorsale misurato all'inizio, a metà e alla fine della prova è risultato pari a 11, 18 e 24 mm rispettivamente e, anche per questo parametro, non sono state rilevate differenze statisticamente significative tra i due gruppi sperimentali.

Rispetto alla prima prova di alimentazione, nella seconda sono stati testati gli effetti di mangimi contenenti più elevate proporzioni di soia integrale (20%) in soggetti di minore peso vivo (tabella 6). La sostituzione di soia integrale tostata (gruppo SIT) con soia cruda di una varietà contenente un ridotto titolo di fattori antinutrizionali (gruppo SIBA) ha determinato una riduzione degli accrescimenti ponderali che ha raggiunto la significatività statistica ($P<0{,}01$) nel corso della prima fase di allevamento (1,10 vs. 0,97 kg). Complessivamente, quindi, i soggetti che ricevevano soia cruda hanno raggiunto un peso finale di circa 10 kg inferiore rispetto a quelli alimentati con soia trattata termicamente, anche se le differenze tra i due gruppi sperimentali non sono risultate statisticamente significative a causa dell'elevata variabilità individuale. Gli apporti alimentari, *ad libitum* fino al peso vivo di 100 kg, sono stati simili tra i due gruppi sperimentali. Gli indici di conversione alimentare sono risultati in linea con le attese e, nella prima fase di allevamento, sono stati peggiori tra i soggetti alimentati con soia cruda rispetto a quelli che ricevevano soia tostata (2,61 vs. 2,33 rispettivamente) come conseguenza dei differenti accrescimenti ponderali.

Per quanto riguarda lo stato di ingrassamento, non si sono osservate differenze di rilievo nello spessore del grasso dorsale imputabili alle due fonti di soia utilizzate nella formulazione dei mangimi sperimentali.

Complessivamente quindi, nonostante il seme di soia di varietà Hilario presenti un contenuto di fattori antitripsinici inferiore alle varietà normalmente disponibili sul mercato, il suo utilizzo in forma cruda sembra esercitare un effetto negativo sugli accrescimenti ponderali, anche se limitatamente alla fase iniziale di allevamento in soggetti con un peso vivo inferiore ai 70 kg. Nelle successive fasi di allevamento non sono stati rilevati effetti negativi sulle performance produttive.

Effetti sulle caratteristiche quali-quantitative delle carcasse alla macellazione

Nelle due prove di allevamento, l'impiego della soia integrale cruda (gruppo SIBA) in sostituzione di un'analoga proporzione di soia tostata (gruppo SIT) non ha determinato differenze significative tra i gruppi sperimentali per quanto concerne sia il peso delle mezzene e la resa di macellazione a freddo che il peso dei reni e del fegato (Tabella 7). Analogamente, il grasso di rifilatura delle cosce ha presentato un profilo acidico simile

Tabella 6 - Effetto dei mangimi sperimentali sulle performance di allevamento nelle due prove di allevamento.

Parametri	Prova 1			Prova 2		
	Mangime		*DS*	Mangime		*DS*
	SIT	SIBA		SIT	SIBA	
Peso vivo, kg						
- inizio prova	70	71	2	37	36	7
- fine 1° fase	154	159	18	77^a	71^b	13
- fine 2° fase	-	-	-	104	100	12
- fine prova	180	181	17	177	167	17
Accrescimento ponderale, kg/d						
- 1° fase	1,143	1,222	0,291	1,102^A	0,969^B	0,205
- 2° fase	0,605	0,512	0,262	0,922	0,949	0,155
- 3° fase	-	-	-	0,847	0,816	0,115
- medio	0,925	0,934	0,163	0,940	0,879	0,087
Consumo alimentare[1], kg/capo/d						
- 1° fase	4,26	4,31	-	2,57	2,53	-
- 2° fase	4,23	4,58	-	3,21	3,17	-
- 3° fase	-	-	-	3,62	3,46	-
- medio	4,24	4,42	-	3,28	3,18	-
Indice di conversione [1]						
- 1° fase	3,72	3,53	-	2,33	2,61	-
- 2° fase	6,99	8,96	-	3,48	3,34	-
- 3° fase	-	-	-	4,27	4,24	-
- medio	4,59	4,74	-	3,54	3,61	-

SIT= soia integrale tostata; SIBA= soia integrale con un basso contenuto di fattori antinutrizionali; DS= deviazione standard;
Prova 1: 1° fase 63 d, 2° fase 43 d, totale prova 106 d; Prova 2: 1° fase 37 d, 2° fase 30 d, 3° fase 84 d, totale prova 151 d;
[1] medie grezze dei consumi giornalieri per box (2 box per dieta).

tra i due gruppi sperimentali ma, come atteso, si è caratterizzato per un elevato grado di insaturazione (numero di iodio mediamente pari a 77 e 74 g/g rispettivamente nelle due prove). E' noto, infatti, che la composizione acidica del grasso corporeo del suino rispecchia la composizione dei lipidi apportati con la dieta. L'aggiunta ai mangimi di soia integrale, composta per circa il 20% della sostanza secca da olio, apporta all'animale un'elevata quantità di acidi grassi insaturi che, una volta assorbiti a livello intestinale, sono direttamente accumulati nei tessuti di deposito. Un elevato grado di insaturazione del grasso accumulato nei tessuti corporei è positivo dal punto di vista nutrizionale per l'uomo ma, da un punto di vista tecnologico (trasformazione in salumi), determina una riduzione della consistenza del grasso e una maggiore suscettibilità all'irrancidimento dei prodotti, che quindi potrebbero presentare una minore conservabilità. Questo problema deve essere tenuto ben presente quando le cosce sono destinate alla produzione di prosciutti crudi tutelati (circuito DOP) a lunga stagionatura, in quanto i disciplinari di produzione raccomandano un grado di insaturazione del grasso di copertura espresso come numero di iodio, inferiore a 70.

Considerazioni

L'impiego del 20% di soia cruda di una varietà con un ridotto contenuto di fattori antinutrizionali, in alternativa ad analoghe proporzioni di soia tostata "convenzionale", nei mangimi per suini ha determinato una riduzione negli accrescimenti ponderali, limitatamente alla fase compresa tra i 35 e i 70 kg di peso vivo. Questi effetti possono essere ricondotti alla riduzione della digeribilità e dell'assorbimento intestinale degli amminoacidi. A pesi vivi più elevati, l'impiego di varietà di soia caratterizzate da un ridotto contenuto di IT non ha avuto effetti negativi sulle performance e sugli indici di conversione alimentare. Inoltre, per l'intera durata della prova, i suini non hanno manifestato particolari problemi di salute. Soprattutto nelle fasi finali del ciclo di allevamento, il limite maggiore nell'impiego della soia integrale sembra quindi rappresentato dal notevole apporto di acidi grassi insaturi, in particolare quando i suini sono destinati alla produzione di prosciutto o di altri prodotti commerciali stagionati che prevedono un contenuto massimo di acido linoleico nella razione alimentare del 2%. Per queste destinazioni produttive, si può quindi suggerire l'utilizzo nelle diete di proporzioni di soia integrale superori al 5% solo quando la formulazione alimentare preveda l'impiego di alimenti particolarmente poveri di grassi insaturi (ad esempio: orzo e frumento in sostituzione al mais).

Tabella 7 - Effetto dei due mangimi sperimentali su alcuni parametri rilevati al macello e sulla composizione acidica (%EE) del grasso di rifilatura della coscia.

	Prova 1			Prova 2		
	Mangime		DS	Mangime		DS
	SIT	SIBA		SIT	SIBA	
Parametri di macellazione:						
- Mezzena sinistra + testa, kg	75,2	76	7,7	73,4	69,6	6,8
- Mezzena destra, kg	70,1	70,5	7,5	69,0	65,1	7,1
- Carcassa, kg	145,3	146,5	15,1	142,4	144,7	13,8
- Resa a freddo, %	80,60	80,70	0,16	80,4	80,6	1,6
- Carne, kg	-	-	-	63,9	62,5	5,7
- Grasso, kg	-	-	-	31,4	32,3	5,7
- Carne magra, %	-	-	-	47,4	47,0	2,9
- EUROP 1	-	-	-	2,97	3,17	0,53
- Reni, g	565	559	82	445,0	458,3	59,9
- Fegato, g	2397	2380	295	2180	2092	230
- Pancreas, g	-	-	-	246,8	232,5	28,9
Composizione acidica del grasso di rifilatura della coscia (% degli acidi grassi totali)						
- SFA	33,0	33,0	1,4	36,3	36,7	1,5
- MUFA	40,4	40,6	1,7	37,3	37,1	0,9
- PUFA	25,6	25,7	1,7	25,4	25,2	1,4
- N° di iodio, n.	77,5	77,4	1,6	74,1	74,6	2,3
- $\sum \omega 3$	2,2	2,1	0,1	2.0	1,9	0,1
- $\sum \omega 6$	23,2	23,4	1,6	23,2	23,2	1,3

SIT= soia integrale tostata; SIBA= soia integrale con un basso contenuto di fattori antinutrizionali; DS= deviazione standard; SFA= acidi grassi saturi; MUFA= acidi grassi monoinsaturi; PUFA= acidi grassi polinsaturi.

Effetti dell'impiego della soia integrale cruda a basso contenuto di fattori antinutrizionali nell'alimentazione di vitelloni all'ingrasso

La prova sperimentale condotta sui bovini all'ingrasso è iniziata ad ottobre 2006 e si è conclusa a maggio 2007, coprendo quindi un intero ciclo di ingrasso di sette mesi. Gli animali, provenienti dalla Francia, sono stati stabulati presso le strutture zootecniche dell'Azienda Agraria Sperimentale "L.Toniolo" dell'Università di Padova (Legnaro, PD).

Disegno sperimentale

Cinquantasei vitelloni di razza Limousine, del peso vivo iniziale di circa 287 kg, sono stati suddivisi in 14 gruppi corrispondenti ad altrettanti box (4 animali per ogni box) in modo omogeneo rispetto al peso vivo iniziale. Sono stati considerati quindi quattro gruppi sperimentali (SIBA, FES, SIT, SINT) che corrispondevano a quattro diverse integrazioni proteiche. Tali integrazioni venivano somministrate agli animali, successivamente alla distribuzione della razione unifeed, con la tecnica del top-dressing, cioè mediante una distribuzione manuale sopra la razione, quindi adeguatamente mescolate con una quota di unifeed in modo da permettere una distribuzione uniforme. Le quattro tesi sperimentali erano le seguenti:

- soia integrale (varietà Hilario) a basso contenuto di fattori antinutrizionali (SIBA)
- farina di estrazione di soia (FES)
- soia integrale tostata (SIT)
- soia integrale non tostata (SINT) di produzione nazionale

I vitelloni sono stati allevati per 222 giorni e macellati al peso vivo medio di 587 Kg.

Diete sperimentali

All'arrivo, gli animali sono stati alimentati con una dieta di condizionamento (a secco) per un periodo di 25 giorni, per permettere un adeguato periodo di adattamento alle nuove condizioni di allevamento, quindi sono state somministrate le diete sperimentali formulate in modo da risultare isoenergetiche e isoproteiche. Complessivamente, l'apporto proteico delle diverse soie utilizzate costituiva il 43% della proteina totale della razione.

Le razioni, preparate e somministrate con l'uso del carro miscelatore, erano costituite da una dieta base, uguale per tutte le tesi sperimentali, composta dai seguenti alimenti: insilato di mais, paglia, mais laminato, crusca, integratore vitaminico-minerale, polpe secche di barbabietole. La quantità di unifeed era somministrata *ad-libitum*, sulla base del residuo alimentare lasciato in mangiatoia dai soggetti del box il giorno precedente.

Tabella 8 - Formulazione della razione di avviamento (kg)

	Tesi sperimentali			
Alimenti	SIBA	FES	SIT	SINT
Insilato di mais	5,60	5,60	5,60	5,60
Mais laminato	2,30	2,30	2,30	2,30
Polpe secche di bietola	1,20	1,20	1,20	1,20
Paglia	0,30	0,30	0,30	0,30
Crusca di frumento	1,00	1,00	1,00	1,00
Integratore vitaminico minerale*	0,25	0,25	0,25	0,25
Grasso saponificato **	-	0,246	-	-
Farina di estrazione di soia	-	1,1	-	-
Soia a basso contenuto di fattori antinutrizionali	1,39	-	-	-
Soia integrale tostata	-	-	1,39	-
Soia integrale non tostata	-	-	-	1,39
TOTALE	12,04	12,00	12,04	12,04

*Integrazione per kg: vit A 240000 UI, vit. D3 15000 UI, vit. E(a-Tocof. 91%) 500 mg, vit B1 80 mg, vit B12 0.4 mg, vit PP 2040 mg, Manganese 650 mg, Rame (solf.rameico pent.) 100 mg, Cobalto (carb. Basico di 0.4 cobalto monoid.) 12 mg, Iodio (iod.potassio) 20 mg, Zinco (Ossido zinco) 1680 mg, Selenio (Se sodico) 3 mg, Zilfo polv. (S 99%) 11200 mg.
** Integrazione per kg: Etossichina (50 mg/Kg), butildrossitoluene (BHT) 100 mg, vit. PP (Acido nicotinico): 10 mg, Manganese (Solfato manganoso tetraidrato): 30 mg

Tabella 9 - Composizione chimica della razione di avviamento

	Tesi sperimentali			
Parametro	SIBA	SIBA	SIBA	SIBA
- Sostanza secca, %	63,0	62,9	63,0	62,9
- Proteina grezza, % ss	13,8	14,0	14,1	14,1
- Estratto etereo, % ss	5,6	5,7	5,9	6,0
- Fibra grezza, % ss	14,4	13,8	14,4	14,4
- NDF,% ss	31,2	30,1	31,2	30,6
- Amido, % ss	30,1	29,8	30,1	30,1
- UFC n/kg*	0,976	0,995	0,976	0,976

*UFC = unità foraggere carne (sistema INRA)

A questa dieta di base venivano aggiunte le diverse soie in relazione alla tesi di riferimento. In particolare, la soia integrale cruda a basso contenuto di fattori antinutrizionali (SIBA), la farina di estrazione di soia (FES), la soia integrale tostata (SIT) e la soia integrale non tostata (SINT) erano aggiunte in quantità tale da apportare 463 g di proteina. Poiché nel caso delle soie integrali (SIBA, SIT, SINT) aumentava nella dieta il contenuto di lipidi grezzi (234 g) a causa della presenza dell'olio, nella dieta FES per equilibrare il livello di lipidi grezzi (e quindi di energia), è stato incluso un grasso saponificato (Maxifat) in quantità pari a 234 g. Nelle tabelle 8 e 9 sono riportate la formulazione e la composizione chimica della razione utilizzata nella fase di avviamento.

Al raggiungimento del peso di circa 400 kg degli animali, alla razione è stato aggiunto 1 kg di farina di mais laminato per proseguire il ciclo produttivo con la fase di finissaggio (razione di finissaggio).

Rilievi sperimentali

I rilievi sperimentali, durante tutto il periodo di prova, hanno riguardato i principali parametri zootecnici in vivo: l'accrescimento individuale, mediante pesate mensili e l'ingestione alimentare giornaliera, mediante pesate giornaliere della quantità somministrata e di residuo alimentare lasciato in mangiatoia. Sono state valutate le condizioni di salute degli animali attraverso il rilievo giornaliero dello stato sanitario nonché mediante la valutazione dei principali parametri metabolici (prelievi ematici, di liquido ruminale e di feci).

Alla macellazione, avvenuta dopo 222 giorni di sperimentazione, sono stati registrati alcuni parametri di caratterizzazione delle carcasse. Su ciascun soggetto è stato rilevato il peso della carcassa a caldo subito dopo la macellazione per la determinazione della resa, la valutazione della conformazione della carcassa in base alla griglia SEUROP e lo stato di ingrassamento degli animali, attribuendo un punteggio da 1 a 5 alle diverse regioni della carcassa secondo i criteri e le metodologie EAAP-CEE.

Su tutte le mezzene destre è stato rilevato il pH a 3 ore e a 8 ore dalla macellazione. Sulle mezzene destre scelte per il prelievo del taglio campione è stato effettuato inoltre il rilievo del pH a 24 ore dalla macellazione.

Su metà delle carcasse è stato inoltre prelevato il taglio campione di *Longissimus thoracis et lomborum* (tra l'ottava vertebra toracica e la prima vertebra lombare) per la determinazione della composizione chimico-nutrizionale (acqua, proteine, grasso, colesterolo, profilo acidico), pH, colore, perdite di cottura e resistenza al taglio.

RISULTATI

I mangimi sperimentali

Si è voluto in primo luogo caratterizzare le diverse tipologie di soia incluse nelle 4 diete sperimentali dal punto di vista nutrizionale con le determinazioni analitiche riportate in tabella 10. Il contenuto proteico della soia a basso contenuto di fattori antinutrizionali, appartenente alla cultivar Hilario è risultato pari a 37,5% ss, in linea con i dati ottenuti in altre prove sperimentali. Questo valore di proteina grezza è risultato tendenzialmente più basso rispetto a quello delle varietà di soia nazionale convenzionali, sia considerando il prodotto tostato che non tostato (38,7 e 39,7% ss rispettivamente). Relativamente alla determinazione dell'attività ureasica, che rappresenta un indice della presenza di fattori antinutrizionali e della solubilità delle proteine ed è espressa come variazione di pH, sono emersi, come atteso, valori più alti (in media 2,31) per le soie crude e sostanzialmente ridotti nel caso della soia tostata (0,21). Si può notare, inoltre, per quanto riguarda l'attività dell'inibitore della tripsina espressa in mg di tripsina inibita per grammo di proteina, sia molto elevata (68 mg/g) nella soia integrale cruda non tostata, mentre risulti più che dimezzata nella soia integrale a basso contenuto di fattori antinutrizionali (27 mg/g). Al contrario, è quasi assente nella soia tostata (12 mg/g).

Riguardo infine alla composizione chimica della farina di estrazione di soia si può evidenziare una sostanziale analogia con i dati riportati in letteratura e valori molto contenuti di attività ureasica e di attività dell'inibitore della tripsina, che sono legati al trattamento termico subito da questo prodotto nella fase di lavorazione.

Effetti sulle prestazioni infra-vitam

Durante la prova 5 animali hanno evidenziato alcuni problemi sanitari. L'incidenza delle patologie (8.9%) è in linea con quella riportata nella media degli allevamenti intensivi di bovini da carne, ma non è risultata direttamente collegabile a una tesi sperimentale. Questo risultato concorda con quanto rilevato da Snidaro et al. (2005) che, in una prova di confronto fra diete contenenti soia a basso contenuto di fattori antinutrizionali e farina di estrazione di soia, non hanno ottenuto, su vitelloni Simmental, differenze sostanziali fra le tesi sperimentali nell'incidenza di problemi sanitari e di mortalità.

Dal profilo metabolico non sono emersi segnali di dismetabolie in atto, se si esclude un tendenziale aumento del livello ematico

Tabella 10 - Caratteristiche chimiche e nutrizionali delle diverse soie impiegate nella prova.

Parametro	Soia a basso contenuto di fattori antinutrizionali	Farina di estrazione di soia	Soia integrale tostata	Soia integrale cruda non tostata
- Sostanza secca, %	90,1	88,4	89,3	88,2
- Proteina grezza, % ss	37,5	47,6	38,7	39,7
- Estratto etereo, % ss	18,0	2,4	20,7	20,2
- NDF, % ss	16,9	12,6	15,5	13,3
- Ceneri, % ss	5,3	6,9	5,4	5,1
- Attività ureasica, Δ pH	2,27	0,18	0,21	2,35
- Attività antitripsinica, mg tripsina inibita/g proteina	27	-	12	68

di GGT (gamma-glutamin-transferasi), indicatore della funzionalità epatica, rilevato a circa metà del ciclo di ingrasso nei soggetti SIBA, ma nella norma rispetto agli intervalli di normalità.
Gli accrescimenti sono stati particolarmente bassi nei bovini che ricevevano soia tostata, che sono anche stati caratterizzati da ingestioni di sostanza secca più ridotte (Tabella 11; Grafico 2 e 3). La velocità di crescita dell'intero ciclo produttivo del gruppo SIBA risulta comunque superiore a quella del gruppo che riceveva la soia tostata (SIT) e, anche se non in modo significativo, a quella del gruppo che riceveva la soia non tostata (SINT), grazie soprattutto agli incrementi realizzati nella fase di finissaggio.

Grafico 2 - Andamento dell'ingestione di sostanza secca durante la prova (SIBA= soia integrale a basso contenuto di fattori antinutrizionali; FES = farina di estrazione di soia; SIT = Soia integrale tostata; SINT= soia integrale non tostata).

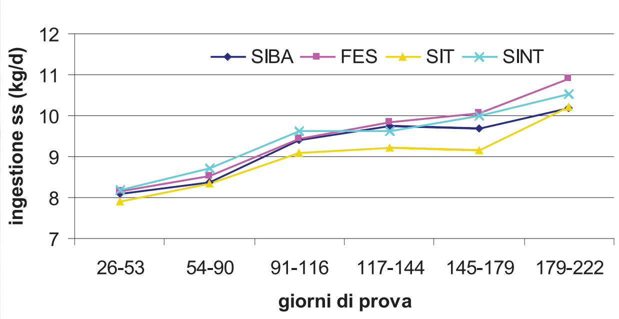
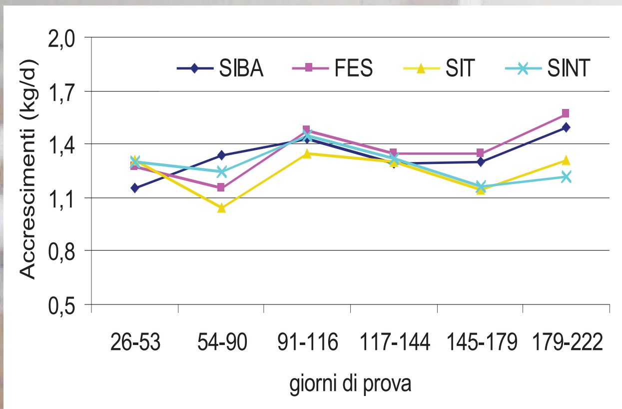


Tabella 11 - Effetto dei mangimi sperimentali sulle performance di allevamento.

Parametro	Tesi sperimentale				
Peso vivo, kg	SIBA	FES	SIT	SINT	*DS*
- Inizio prova	285,7	288,4	282,7	290,4	17,0
- Inizio fase avviamento	334,4	330,5	315,6	332,5	17.5
- Inizio fase ingrasso	454,5	447,4	426,4	453,3	35.4
- Fine prova	601,1	600,1	559,4	583,6	51.5
Accrescimento ponderale, kg/d					
- Inizio avviamento - Inizio ingrasso	1.51	1.37	1.23	1.41	0.39
- Inizio ingrasso - Fine prova	1.39	1.44	1.28	1.29	0.38
- Inizio avviamento - Fine prova	1.44	1.41	1.26	1.34	0.38
Consumo alimentare, kg ss/capo/d					
- Inizio avviamento - Inizio ingrasso	8.90	10.48	9.71	10.26	0.63
- Inizio ingrasso - Fine prova	9.94	10.48	9.71	10.26	0.69
- Inizio avviamento - Fine prova	9.25	9.50	8.95	9.45	0.65

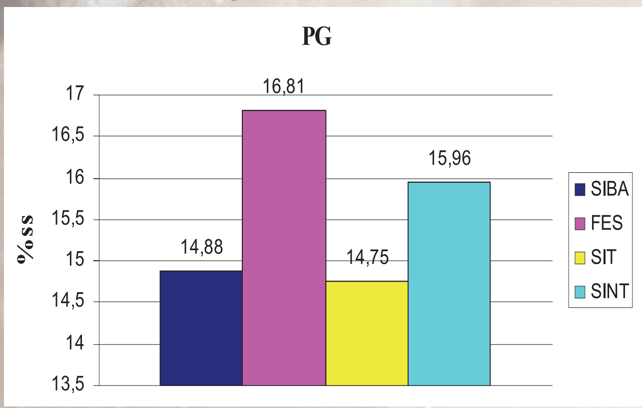
Inizio fase avviamento 25 d; Inizio fase ingrasso = 117 d; Totale prova = 222 d; DS = Deviazione Standard

Grafico 3 - Accrescimenti medi giornalieri durante la prova (SIBA= soia integrale a basso contenuto di fattori antinutrizionali; FES = farina di estrazione di soia; SIT= Soia integrale tostata; SINT= soia integrale non tostata).



Nei soggetti del gruppo SIBA il tenore di proteina grezza nelle feci è risultato molto basso e molto simile a quello della tesi SIT (soia tostata), a conferma di un probabile abbattimento dei fattori antinutrizionali di questa varietà di soia, con particolare riguardo a quelli antitripsinici responsabili di una ridotta utilizzazione digestiva della proteina (Grafico 4). Per meglio evidenziare i valori di digeribilità della proteina sarebbe stato necessario effettuare una vera e propria prova di digeribilità in vivo utilizzando i metodi ufficiali, tuttavia i risultati ottenuti in questa prova possono fornire alcune indicazioni preliminari su questo aspetto.

Grafico 4 - Tenore di PG (%ss) delle feci nelle diverse tesi sperimentali (SIBA= soia integrale a basso contenuto di fattori antinutrizionali; FES = farina di estrazione di soia; SIT= Soia integrale tostata; SINT= soia integrale non tostata).



Effetti sulle caratteristiche quali-quantitative delle carcasse alla macellazione e della carne

Le prestazioni *post-mortem* sono risultate molto simili tra le varie tesi sperimentali, soprattutto per quanto riguarda le caratteristiche delle carcasse. Il peso vivo dei vitelloni a fine prova ha raggiunto un valore medio di 587 kg, da ritenersi ottimale per soggetti di razza Limousine in allevamento intensivo (Tabella 12), senza mostrare differenze fra le tesi. Lo stesso riguarda la resa, a caldo, risultata mediamente buona (63,8%). La valutazione SEUROP delle carcasse, effettuata da un esperto, ha evidenziato un valore medio di 3,23 corrispondente ad una conformazione di tipo U, considerata ottima, cioè con profili nell'insieme convessi e uno sviluppo muscolare abbondante. Per quanto riguarda lo stato di ingrassamento, si può evidenziare che mediamente la valutazione è stata pari a 2,56, punteggio intermedio tra scarsa copertura di grasso con muscoli quasi ovunque apparenti (punti 2) e copertura mediamente importante in cui i muscoli si presentano quasi ovunque ricoperti di grasso (punti 3).

Sia la composizione chimica che le proprietà fisiche della carne, valutata utilizzando come campione di riferimento il *Longissimus thoracis et lomborum,* risultano simili tra le diverse tesi sperimentali (Tabella 13). Solamente per quanto riguarda il colore sono emerse differenze statisticamente significative e la carne del gruppo SIBA ha presentato un indice del rosso e del giallo più bassi rispetto alle due tesi con soia integrale.

Dal punto di vista nutrizionale sono state riscontrate delle differenze nel profilo acidico del taglio campione. Tra gli acidi grassi saturi, l'acido miristico e palmitico che sono considerati i più nocivi per la salute umana, sono risultati meno presenti nella carne del gruppo SIBA rispetto il gruppo delle due soie integrali. Gli acidi grassi polinsaturi, alleati per diminuire il colesterolo nel sangue, sono risultati presenti in quantità maggiori della tesi SIBA e tra questi gli acidi grassi della serie w3 in particolare. Per quanto riguarda i coniugati dell'acido linoleico (CLA), che svolgono un ruolo importante nella prevenzione di alcuni tumori e di altre patologie comuni nelle popolazioni occidentali, non si sono riscontrate differenze fra le tesi sperimentali. Sia l'indice aterogenico che quello trombogenico (parametri nutrizionali legati all'incidenza di malattie cardiocircolatorie) risultano più bassi e quindi più favorevoli nella carne proveniente dai soggetti alimentati con la soia a basso contenuto di fattori antinutrizionali.

Tabella 12 - Caratteristiche delle carcasse dei vitelloni al macello.

Parametro	Tesi sperimentale				*DS*
	SIBA	FES	SIT	SINT	
Peso finale, kg	602,5	600,1	559,4	583,6	50,1
Peso della carcassa, kg	385,5	383,8	357,6	369,9	31,2
Resa (%)	64,1	63,9	63,9	63,4	2,4
SEUROP *	3,27	3,33	3,25	3,12	0,4
Stato di ingrassamento **	2,53	2,33	2,50	2,81	0,5

* Scala di valori SEUROP da 5=Superiore; 4=Eccellente; 3=Ottima; 2=Buona; 1=abbastanza buona; 0=mediocre.
** Scala di valori dello stato di ingrassamento: da 5=molto abbondante; 4=abbondante; 3=mediamente importante; 2=scarso; 1=molto scarso.

Tabella 13 - Composizione chimica, parametri fisici e qualitativi della carne (muscolo *Longissimus thoracis et lomborum*).

Parametro	Tesi sperimentale				*DS*
	SIBA	FES	SIT	SINT	
Composizione chimica					
- Sostanza secca, %	24,51	24,53	25,16	24,72	0,36
- Estratto etereo, % ss	1,04	1,33	1,51	1,25	0,39
- Proteina grezza, % ss	22,22	22,06	22,50	22,36	0,32
- Ceneri, % ss	1,25	1,13	1,15	1,11	0,23
pH	5,44	5,43	5,43	5,44	0,03
Perdite di cottura, %	27,54	28,54	26,63	26,09	5,24
Sforzo di taglio, kg/cm2	2,66	2,82	2,72	2,95	1,46
Colore					
- Luminosità (L*)	38,60	39,01	38,25	39,18	2,62
- Indice del rosso (a*)	10,41	10,76	11,68	10,92	1,56
- Indice del giallo (b*)	12,63	12,89	13,12	13,04	1,77
Profilo acidico, % sul totale					
- Acidi grassi saturi	46,64	48,53	49,05	47,68	2,18
- C14:0 (Miristico)	2,30	2,72	2,84	2,58	0,39
- C16:0 (Palmitico)	23,12	27,70	24,91	24,21	1,31
- Acidi grassi monoinsaturi	34,45	38,03	36,17	37,03	3,02
- Acidi grassi polinsaturi	17,35	12,21	13,43	13,42	3,69
- Rapporto $\sum\omega6 / \sum\omega3$	11,88	12,73	12,42	12,28	2,36
- Coniugati acido linoleico (CLA)	0,36	0,43	0,39	0,37	0,09
Indice aterogenico	0,63	0,77	0,73	0,69	0,07
Indice trombogenico	1,53	1,71	1,72	1,63	0,16

Considerazioni

L'impiego della soia a basso contenuto di fattori antinutrizionali non ha evidenziato particolari problemi di carattere sanitario e ha consentito ai bovini all'ingrasso di raggiungere prestazioni produttive buone e superiori, anche se non in modo significativo, sia a quelle degli animali che ricevevano la soia dalle varietà convenzionali cruda (cioè non sottoposta a trattamenti termici) sia a quelle dei soggetti che assumevano la soia tostata. I parametri metabolici non sono stati influenzati dall'utilizzo della soia SIBA, eccetto che per l'aumento dell'enzima GGT a circa metà del ciclo d'ingrasso. L'impiego di questa soia non ha condizionato significativamente la qualità delle carcasse e le proprietà chimiche della carne, con valori molto simili a quelli delle altre due tesi con seme intero. Il colore della carne risulta differente con un indice del giallo e del rosso più basso nella tesi SIBA rispetto alle due tesi con soie convenzionali intere. Dal punto di vista nutrizionale è emerso che la carne ottenuta da soggetti alimentati con la soia a basso contenuto di fattori antinutrizionali, presenta un profilo acidico più favorevole al mantenimento della salute umana, con una maggior incidenza di acidi grassi che svolgono un ruolo positivo nell'organismo.

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LEGENDA ABBREVIAZIONI

OGM = organismi geneticamente modificati
ANF = fattori antinutrizionali
IT = inibitori tripsinici
SIBA = soia integrale a basso contenuto di fattori antinutrizionali
FES = farina di estrazione di soia
SIT = soia integrale tostata
SINT = soia integrale non tostata
PV = peso vivo
DS = deviazione standard
UFC = unità foraggere carne
SFA = acidi grassi saturi
MUFA = acidi grassi monoinsaturi
PUFA = acidi grassi polinsaturi
CLA = coniugati dell'acido linoleico
EE = estratto etereo
EM = energia metabolizzabile
GGT = enzima gamma-glutamin-trasferasi

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