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RESEARCH ARTICLE

Holstein-Friesian milk performance in organic farming in North Spain: Comparison with other systems and breeds

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Abstract

Organic systems are highly dependent on the environment and require animals well adapted to local conditions. In Spain, organic dairy farmers are not satisfied with the productive performance of their herds and ask for technical advice to obtain suitable animals for organic systems. The milk productive performance (milk yield, nutritional composition, and somatic cell count) of Holstein-Friesian cows in organic farming in North Spain compared with conventional farms has been analysed. When breed diversity was present in the same organic farm, Holstein-Friesian milk performance was compared with other breeds and/or crosses. Holstein-Friesian cows in organic farming produce slightly less milk than grazing conventional cows, but milk was similar in composition and somatic cell count across systems. The limited data from organic farms where breed diversity exists indicate that Holstein-Friesian cows produce numerically more milk than other breeds and crosses but with statistically lower protein content. Considering that in Spain organic milk production is mostly used for liquid milk consumption and that the payment system is based only on milk volume, Holstein-Friesian cows would better fit the farmer interests than other breeds or crosses. However, in addition to productive performance, reproductive efficiency, animal health and consumer's preferences should be fully considered when selecting a breed for organic production. If Holstein-Friesian was the selected breed, efforts should be made to identify cows within the breed that are best adapted to organic conditions. New productive, reproductive, nutritional and economic studies would be needed to develop a genetic merit index for organic systems.

Additional key words: dairy cattle; milk composition; crosses; suitability; production systems.

Abbreviations used: DCR (dairy control record); FS (farm system); LG (lactation group); SCC (somatic cell count).

Authors' contributions: Conceived and designed the experiments: MM and MLA. Performed the experiments: RRB, IO and FRC. Analyzed the data: RRB, IO, NM and MLA. Wrote the paper: RRB.

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Introduction

Organic farming promotes a combination of providing good-quality feedstuffs, no use of chemical products, appropriate livestock husbandry systems and correct management practices to deal with the principles of health, ecology, fairness and care (IFOAM, 2012). Organic systems are highly dependent of the environment (Falconer & Mackay, 1996), and to deal with these principles the European Union organic regulation (EC, 2007) specifically states that the choice of breeds should take into account their capacity to adapt to local conditions, their vitality and their resistance to disease or health problems.

During the last half of the 20th century, dairy genetic selection was nearly exclusively focused on the Holstein-Friesian breed to greatly improve milk production. The resulting cow could be considered a high maintenance animal for highly standardised intensive systems, an environment that clearly differs from that of organic production, mainly regarding feeding regimens and medical treatments (Ahlman, 2010). In parallel, this selection process has resulted in reduced reproductive efficiency, extended calving intervals, increased health problems, increased culling rates, and decreased productive life (González-Recio *et al*., 2006; Bluhm, 2009) especially when these highly selected cows are out of intensive nutritional and environmental management systems. The most notable exception to the high-producer Holstein-Friesian genetic selection was carried out in Australia and New Zealand, countries with seasonal, site adapted, and pasture-based milk production systems (Macdonald *et al*., 2008; Baudracco *et al*., 2010, 2011) which are closer to the organic principles.

In this context, as organic dairy farming was growing in Europe, farmers realised that the available cows were not adapted to the organic requirements. Cows used in organic farming were similar to those in conventional systems (Endendijk & Baars, 2001; Nauta, 2001) and their suitability for organic productive conditions was questionable in that their potential performance under organic systems was not optimal (Diepen *et al*., 2007). With the aim of solving this problem, experts over the world propose to use Holstein-Friesian cows adapted to organic systems (Baars & Endendijk, 1990; Endendijk & Baars, 2001; Brotherstone & Goddard, 2005), or alternatively other purebred cows (Sundrum, 2001) or their crosses (Nauta *et al*., 2005; Rozzi *et al*., 2007; Begley *et al*., 2009).

In the Netherlands, a survey by Nauta *et al*. (2006a) showed that different production and marketing strategies demand different breeds: some local or native breeds adapt well to the organic systems because they utilize lower quality feed, are more resilient to climatic stress, and are more resistant to local parasites and diseases. Interest in crossbreeding has grown over the past decade among both producers and researchers (Heins *et al*., 2006b) and crossbreeding of Holstein-Friesian and local breeds could help to minimize the decline of health, longevity and fertility by introducing favourable genes, removing inbreeding depression, and taking advantage of heterosis (Lopez-Villalobos *et al*., 2000; Rozzi *et al*., 2007); however this option needs to be further investigated before used on a large scale (Ahlman, 2010).

Organic milk production in Spain is small (16,413 tons/year; MAGRAMA, 2014) but has been growing rapidly in recent years. Organic dairy farmers are not satisfied with the productive performance of their cows, nearly 60% of them would like to have a better adapted breed (Rodríguez-Bermúdez *et al*., 2015). However, due to the difficulty of getting technical advice for acquiring suitable animals, they kept maintaining the same cows as when they were in conventional farming; only a minority (18%) started to incorporate new breeds or use crossbreeding.

The objective of this paper was to analyse the milk productive performance (milk yield, nutritional composition, and somatic cell count) of Holstein-Friesian cows in organic farming in North Spain compared with conventional farms in the region. When breed diversity was present in the same organic farm, milk productive performance of Holstein-Friesian was also compared to the other breed and/or crosses.

Material and methods

Farms involved

Data on which this paper is based were collected from a subset of farms within an extensive research project to evaluate the nutritional and health status of organic dairy cattle in Northern Spain compared with conventional farming. That project involved all (n=56) organic dairy farms of Northern Spain, representing nearly the 80% of organic production in Spain (MAGRAMA, 2013).

For this paper, data of Holstein-Friesian dairy cows from organic (n=9), pasture-based conventional (n=5) and zero-grazing conventional (n=5) farms were used. For those organic farms that presented an appreciable (>10% of herd) breed diversity (n=3) data of the different purebred and crossbred cows were obtained. Detailed productive and management characteristics of these farms are presented in Tables 1 and 2, respectively.

Data collection

Data related to milk production including milk yield, milk composition (% fat, % protein), and somatic cell counts (SCC) were collected in the selected farms from all lactating cows during the last complete lactation finished before December 2015. All farms used on this study were included in the Dairy Control Record (DCR) system. Milk samples were collected in 50 mL plastic containers with the preservative bronopol (2-bromo-2-nitro-1,3-propanediol) previously added. Percentages of fat and protein were determined by infrared spectroscopy and SCC (cell/mL) values using cell counter FOSSOMATIC™ (MilkoScan, Foss, Hillerød, Denmark) according to the manufacturer instructions. All analyses were conducted monthly with data obtained from DCR in LIGAL (Laboratorio Interprofesional Galego de Análise do Leite).

Statistical analyses

All statistical analyses were done by using the SPSS program for Windows (V.21.0). Parameters related to

Table 1. Details of the different Holstein-Friesian farms analysed in Northern Spain. Data are expressed as mean and range in brackets.

	Organic (n=9)	Conventional	
		Pasture-based (n=5)	Zero-grazing (n=5)
Type of farm	Free stall	Free stall	Free stall
Number of milking cows	68.4 (30-207)	55.6 (36-71)	55.8 (32-90)
Milk production (kg /cow·year)	6962 (5696-9089)	7757 (4973-9565)	9987 (7838-12110)
Age of cows (years)	5.14 (2.6-13.5)	4.69 (2.6-11.9)	4.55 (2.5-10.3)
Concentrate intake (kg/animal day)	3.50 (1.82-5.45)	5.28 (3.62-7.18)	6.99 (3.61-10.5)
Forage intake (kg/animal day)	13.5 (9.40-19.2)	15.3 (10.6-18.8)	13.3 (8.24-16.2)
Main activity/Core business	Direct milk sale. Cheese and yogurt manufacturing. Ecoturism	Direct milk sale	Direct milk sale

milk production (milk yield) and composition (% fat and % protein) showed a normal distribution, but SCC data were converted to logarithmic scale in base 10 (logSCC) previously to the statistical analysis to fulfil the Anova assumptions.

Data of Holstein-Friesian cows in organic, conventional pasture-based, and zero-grazing conventional systems were analysed by using Linear Mixed Models where Farm, Farm_System (FS) and Lactation_Group (LG) were placed as factors and milk production parameters (milk yield, % fat, % protein, logSCC) as dependent variables. FS, LG and FS×LG interaction were introduced as fixed factors and Farm as an aleatory factor. Lactation groups were considered as group 1 (including cows of 1st and 2nd parities), group 2 (3rd and 4th parities) and group 3 (5th or more parities). *Post-hoc* analyses (Bonferroni test) were used to subsequent group comparison within each variable.

When considering milk productive performance in Holstein-Friesian and other purebred or crossbred cows when present in the same farm, number of parities was not homogenously distributed within the different breeds. Because of the significant effect of parity on the milk parameters evaluated in this study (as described later) parity could not be introduced as a factor in the analysis, therefore data were analysed in each farm separately by using planned contrasts considering three groups of cows: group 1 (including cows of 1st and 2nd parities), group 2 (3rd and 4th parities) and group 3 (5th or more parities).

Results

Comparison among Holstein-Friesian cows in organic, pasture-based and zero-grazing conventional systems

Summarised data of Holstein-Friesian milk production in organic, pasture-based, and zero-grazing conventional systems by LG are presented in Table 3. Farm System was a significant factor in the Linear Mixed Model (p=0.001) for milk yield. Overall, milk yield was lower in organic farms (22.5 L/day) compared with zero-grazing conventional farms (34.6 L/day) and pasture-based conventional farms (24.8 L/day) having an intermediate position between both. On the contrary, no statistically significant differences were observed between FS for % fat (3.87, 3.58, and 3.88), % protein (3.15, 3.13, and 3.19) and logSCC (5.04, 4.92, and 4.80) for organic, pasture-based and zero-grazing conventional farms, respectively.

Table 2. Details of the organic farms with breed diversity analysed in Northern Spain. Data are expressed as mean and range in brackets.

	Farm#1	Farm#2	Farm#3
Type of farm	Free stall	Free stall	Free stall
Number of milking cows	48	34	111
Milk production (kg/cow · year)	6921 (6200-7300)	5600 (4800-6200)	6500 (6000-6700)
Age of cows (years)	5.5 (2.6-9.3)	6.2 (2.6-11.2)	5.28 (2.6-9.5)
Concentrate intake (kg/animal · day)	5 (5-5)	4 (3-5)	3 (3-3)
Forage intake (kg/animal · day)	14.1 (11.6-17.3)	12.5 (9.4-13.9)	16.0 (12.5-18.1)
Main activity/Core business	Direct milk sale	Ecotourism. Cheese manufacturing	Direct milk sale

Table 3. Summarised data (expressed as mean±SE) of Holstein-Friesian milk production in organic, conventional pasture-based and zero-grazing conventional systems in North Spain. Different letters within the same row indicate statistically significant differences between farm systems (p<0.05). Different numbers within the same column indicate statistically significant differences between lactation groups (LG) (p<0.05).

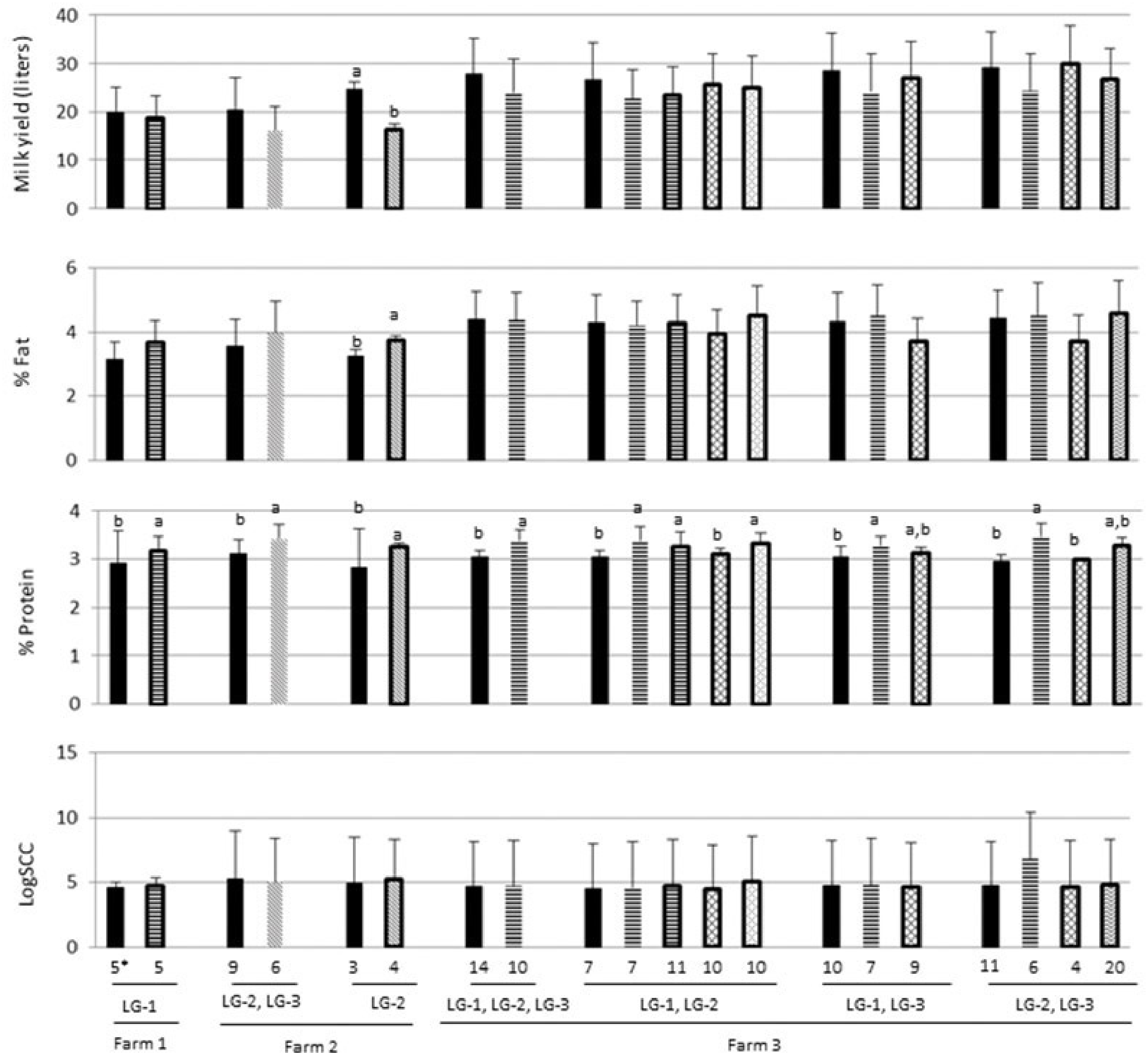
	Organic (n=9)	Conventional	
		Pasture-based (n=5)	Zero-grazing (n=5)
Number of samples			
LG-1	4914	3009	4089
LG-2	3643	1968	2126
LG-3	2336	686	808
Milk, L/day			
LG-1	20.8±6.4^{a1}	23.2±7.7^{a1}	33.1±8.2^{b1}
LG-2	24.0±7.7^{a3}	27.3±8.7^{ab2}	37.0±10.2^{b3}
LG-3	23.6±7.7^{a2}	24.9±8.8^{ab2}	35.9±9.6^{b2}
Fat, %			
LG-1	3.86±0.84^{2}	3.59±0.86^{2}	3.77±1.28^{1}
LG-2	3.92±0.89^{3}	3.63±0.97^{2}	3.81±1.17^{1}
LG-3	3.80±0.95^{1}	3.39±0.90^{1}	3.90±1.13^{2}
Protein, %			
LG-1	3.17±0.41^{2}	3.12±0.36^{2}	3.19±0.40^{2}
LG-2	3.14±0.31^{1}	3.16±0.39^{3}	3.20±00.41^{2}
LG-3	3.12±0.37^{1}	3.08±0.32^{1}	3.16±0.39^{1}
SCC, $\log_{10}(10^3$ cells/mL)			
LG-1	4.90±0.53^{1}	4.79±0.52^{1}	4.68±0.52^{1}
LG-2	5.10±0.58^{2}	4.97±0.59^{2}	4.89±0.63^{2}
LG-3	5.21±0.61^{3}	5.31±0.62^{3}	4.96±0.64^{3}

LG-1=cows at 1st and 2nd lactation; LG-2= cows at 3st and 4nd lactation; LG-3= cows at 5 or more lactation; SCC=somatic cell count

As expected, LG was a significant factor in the analysis for all the milk parameters analysed in this study. In all FS milk yield significantly increased from LG-1 to LG-2 and decreased from LG-2 to LG-3 (Table 3). The increase of milk yield from LG-1 to LG-2 in organic farms (15%) was similar to that observed in conventional farms (12 to 18%), even though the decrease of milk yield from LG-2 to LG-3 was lower (1%) than in conventional farms (3 to 9%). For the nutritional composition parameters (% fat and % protein) variation along LG was lower (generally <5% for fat and <1% for protein) although significant interactions between LG and FS were observed: whereas in organic and pasture-based conventional farms the % fat showed the same pattern as observed for the milk yield (increase from LG-1 to LG-2 and decrease from LG-2 to LG-3 in the zero-grazing conventional systems the % fat progressively increased along the number of lactations. When analysing the % protein, both zero-grazing and pasture-based conventional farms showed the same evolution as the milk yield, although for organic farms % protein progressively decreased from LG-1 to LG-3. Finally, SCC progressively increased with number of lactation in all FS: the increases of SCC from LG-1 to LG-2 and from LG-2 to LG-3 in organic farms (59 and 105%, respectively) were similar to those observed in conventional herds, except that the increase in SCC for the LG-2 to LG-3 in pasture-based conventional farms was about double. Finally, Farm explained the 26.9% of variability for milk production, 20.0% for % fat, 2.52% for % protein and 8.11% for logSCC.

Comparison among Holsteins-Friesian and other purebred or crossbred cows within the same farm in organic systems

Summarised data of milk productive parameters in comparable groups of lactations in farms with appreciable breed diversity (n=3) are presented in Figure 1. The detailed evaluation of the effect of breed only for the comparable groups of parity along the lactation in each farm revealed that breed was a significant factor for the % protein in the three farms, Holstein-Friesian cows showing statistically significant lower values compared to the other breeds or crosses in the same farm. In addition, for the LG-2 in farm#2,



Holstein-Friesian; Swedish Red; Brown Swiss; Holstein-Friesian x Swedish Red; Holstein-Friesian x Brown Swiss Holstein-Friesian x Montbeliarde Holstein-Friesian x Jersey Holstein-Friesian x Fleckvieh. *number of animals.

Figure 1. Milk production in organic farms with breed diversity (n=3). Details of lactation groups (LG) are given in the text. Different letters indicate statistically significant differences between breeds within each LG (p<0.05).

Holstein Friesian × Brown Swiss cows had statistically significant higher % fat (3.73±0.17%) but lower milk production (16.3±1.2 L/day) than pure Holstein-Friesian cows (fat: 3.27±0.20%, milk yield: 24.6±1.7 L/day).

Discussion

Animal productive performance is the result of the interaction between genotype and environment (G×E), this interaction being specially relevant when animals are reared under particular environmental conditions (Diepen *et al*., 2007). When animals are genetically adapted to specific (such as organic production) or extreme conditions they will be more productive and production costs will be lower (Simm *et al*., 2004). In this sense, it has been found that G×E caused a re-ranking of Holstein-Friesian animals between organic and conventional systems for fertility traits in Sweden and production traits in the Netherlands (Nauta *et al*., 2006b), indicating that some Holstein-Friesian cows are better suited for organic production than others (Ahlman, 2010). The results of our study indicate that at the circumstances of dairy farming in North Spain, organic farms produce less milk compared to conventional farms. Overall, organic Holstein-Friesian cows of various LG produced 52 to 59% less milk compared to their counterparts in zero-grazing conventional farms, but only about 10% less than pasture-based conventional farms. Differences in milk yield of Holstein-Friesian cows in organic and pasture-based conventional systems respect to those producing in zero-grazing conventional systems are likely greatly related to nutrition management (Walker *et al*., 2004). Horan *et al*. (2005) observed that Holstein-Friesian cows selected for high production have better milk yield under systems of high concentrate supplementation. As indicated in Table 1, in our study cows in zero-grazing conventional systems are supplemented with higher concentrate compared with the organic and grazing-based conventional groups. Our results are in accordance with a survey conducted in organic farms across 12 European countries that showed a lower milk yield per cow (5 to 25%) in organic than in conventional farms (Offermann & Nieberg, 2000). In addition, Ahlman (2010) showed similar results (lower production in organic) when considering Swedish Holstein and Swedish Red cows in organic and conventional systems in Sweden.

However, in our study in the organic farms where breed diversity exits, Holstein-Friesian cows produce numerically (but not statistically significant) more milk litres than other breeds and crosses. It is well assumed that in zero-grazing conventional systems Holstein-Friesian cows have higher milk yields compared to other breeds (Heins *et al*., 2006a; Bjelland *et al*., 2011), because cows with high genetic potential for milk yield have better responses to supplements (Baudraco *et al*., 2010). In organic systems, information on the effect of breed on milk yield is sparse, although seemingly lower than in conventional systems: organic systems are based on pasture utilisation with low concentrate supplementation, a diet that could make interbreed differences less evident. In fact, when comparing different type of diets in conventional systems, Oldenbroek (1988) found that differences between Holstein-Friesian and other breeds, although always present, were more evident with diets with higher amounts of concentrate compared with those based on forages. Moreover, the evolution of the milk yield along the productive life of our organic Holstein-Friesian cows was very similar to that observed in their conventional counterparts. Milk yield production along the productive life has been well studied (Ray *et al*., 1992; Mellado *et al*., 2011; Ríos-Utrera *et al*., 2013): the increase of milk yield with increased parity is due to differences in the control of tissue mobilization between primiparous and multiparous cows (Wathes *et al*., 2007); lower consumption of feed per day of primiparous cows than multiparous cows (Dado & Allen, 1994), and increasing body size of older cows over that of first-lactation animals (Mellado *et al*., 2011). In general it is assumed that milk yield per lactation increased significantly until 3rd lactation and is maximum between 4th and 5th lactation (Ray *et al*., 1992; Gader *et al*., 2007; Ríos-Utrera *et al*., 2013). The fact that older Holstein-Friesian cows (LG-3) on organic farms were able to better maintain the milk yield could be interpreted as a positive fact. Longevity has decreased in conventional dairy populations due to selection mainly on production traits (Essl, 1998) and milk production has been shown to be unfavourably correlated with functional traits (animal health, longevity, and reproduction) (Ahlman, 2010); this situation leads to cows being culled because of health and fertility reasons, so productive life of modern cows is rapidly declining (Oltenacu & Algers, 2005).

When analysing milk composition (namely % fat and % protein) no statistically significant differences were found between Holstein-Friesian cows in organic systems compared with conventional systems, even though both organic and zero-grazing conventional Holstein-Friesian cows produce milk with numerically high fat content (3.88%) compared with cows in pasture-based conventional systems (3.58%). On the contrary, protein concentrations were less variable and differences between production systems were slight. It is well assumed that fat and protein production is highly related to nutrition (Gordon & McMurray, 1979; King *et al*., 1990; Walker *et al*., 2001), depending not only on the quantity of forage and supplements but also in the composition of them (Palmquist, 1993); Walker *et al*., 2004). Consequently, differences in fat and protein production depend not only on the production system, but also along the year and the region. Ahlman (2010), in a study in Sweden, found lower fat and protein yield in organic farms compared with conventional farms, although the opposite was found in Canada by Rozzi *et al*. (2007).

However, when comparing Holstein-Friesian cows with other breeds/crosses in the same organic farm, all breeds and crosses showed statistically significant higher milk protein concentrations than purebred Holstein-Friesian. On the contrary, differences in the fat content were lower, with the only exception of Holstein × Brown Swiss cows in farm#2 that produced milk with a high fat content compared to pure Holstein-Friesian. It is well assumed that in conventional systems Holstein-Friesian cows produce higher milk volumes but with a lower fat and protein content compared to other breeds such as Brown Swiss, Jersey or Swedish Blond (Oldenbroek, 1988; Heins *et al*., 2006a; Vance *et al*., 2009; Prendiville *et al*., 2011). Crossbred cows may be beneficial under a milk payment scheme that rewards higher components in contrast to systems where the payment is based on milk volume; in those systems care would have to be taken to select breeds, and bulls within breeds that could maintain milk volume (Bluhm, 2009). In organic farming information of the effect of breed on milk composition is sparse. Similarly to milk yield, organic (pasture-based) diets would make the interbreed influence on milk composition less evident compared with those based on large amounts of concentrate (Oldenbroek, 1988).

The evolution of milk composition along the productive life of Holstein-Friesian cows reared on organic farms is very similar to that observed in their conventional counterparties; in general fat and protein concentrations increase from LG-1 to LG-2 and significantly decreases in the LG-3. The only exceptions were the slight (1%) although significant progressive decrease of % protein from LG-1 to LG-3 for the organic Holstein-Friesian cows and the increase of % fat also from LG-1 to LG-3 for the zero-grazing conventional. It is generally assumed that fat and protein percentages decreased when increasing lactation number (Schutz *et al*., 1990; Yoon *et al*., 2004), and we are not aware of the reasons behind this different result apparently related to the production system. We are conscious that the number of farms in our study is small and these results may be due to chance.

When considering the sanitary status of the farms, no significant differences on the SCC were observed between Holstein-Friesian cows from different farm systems or between Holstein-Friesian cows and other breeds or crosses within the same organic farm. As expected, SCC significantly increased with number of lactation in all production systems and breeds (Reneau, 1986), particularly in cows with a high number of lactations (Tancin, 2013). Numerous studies have compared the SCC in organic and conventional farms worldwide, however no consensus has been found. Even though some studies indicate a lower SCC in organic dairy farms (Busato *et al*., 2000; Hamilton *et al*., 2006), most of them found the opposite (Hovi & Roderick, 2000; Zwald *et al*., 2004; Roesch *et al*., 2007; Rozzi *et al*., 2007; Sundberg *et al*., 2009) or very little difference between both production systems (Hardeng & Edge, 2001; Vaarst *et al*., 2006; Fall *et al*., 2008; Haskell *et al*., 2009). In addition to clinical and subclinical udder disease, factors like husbandry, management, genetics, and nutrition and associated metabolic and endocrine changes have some influence on the SCC. In this sense, at a hypothetical identical sanitary condition the lower milk yield and the higher mean age of lactating cows in organic farms compared with conventional farms could leave to a higher SCC in the former (Villar & López-Alonso, 2015). Differences in the udder health between organic and conventional herds are not necessarily only due to a direct effect of the organic management, and many other differences in management routines may exist between organic and conventional farms besides the "purely" organic and such differences might vary across studies (Fall *et al*., 2008). In fact, in studies conducted using identical experimental conditions, no differences were observed between organic and conventional herds (López Villalobos & Scott, 2003; Fall *et al*., 2008; Fall & Emanuelson, 2009). In our study, comparisons between SCC were always made at the same conditions, particularly number of parities and mastitis management (antibiotic based); however, if the SCC count was made at the bulk tank level it would be likely that SCC would be higher in organic herds because the mean age of the herd is higher, and the milk yield lower in organics (Table 1). Our results indicate that at the conditions of organic production of Spain the udder sanitary status is similar to that of conventional systems along all the productive life, and consequently it does not like that Holstein-Friesian cows could have a higher risk to suffer udder disorders related to a lack of adaptation to the productive system.

In conclusion, the detailed evaluation of milk productive performance of organic dairy farms in North Spain, by comparing Holstein-Friesian cows (the main dairy breed in the region) from different production systems and, within the same organic farm, with other breeds and their crosses, did not show a lack of adaptation of Holstein-Friesian cows to the organic conditions. In organic farms, Holstein-Friesian cows produce slightly less milk (10%, but with a lower ingestion of concentrate) that in pasture-based conventional farms, but milk was similar in nutritional composition and for somatic cell counts. The limited available data from organic farms where breed diversity exists indicate that Holstein-Friesian cows produce numerically more milk than other breeds and crosses but with statistically lower protein content. Considering that in Spain organic milk production is mostly applied to liquid milk consumption and that the payment system is only based on milk volume, Holstein-Friesian cows would better fit the farmer interests than other breeds or crosses; in fact only 13% of organic farmers would consider the milk solid concentration as a relevant trait when selecting their cows. Other advantages of using Holstein-Friesian in organic dairy farming are more available information and fewer difficulties to find replacement heifers compared with other breeds. However, in addition to the productive performance, other parameters related to reproductive efficiency, animal health and consumer's preferences should be fully considered when choosing Holstein-Friesian or other breeds or crosses for organic dairy. If finally, Holstein-Friesian was the selected breed, efforts should be made to find the cow best adapted to the organic conditions. New productive, reproductive, nutritional and economic studies would be needed to develop a genetic merit index for organic systems. This genetic merit index could be useful not only for organic dairy systems but would also be relevant for pasture-based conventional systems.

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