Is lack of antibiotic usage affecting udder health status of organic dairy cattle?

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Short title: Udder health regarding antibiotic usage

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Summary

This research communication aimed to compare somatic cell count (SCC), the main marker of udder health status, in organic farms not using antibiotics (O, n=6), organic farms using antibiotics (OA, n=7) and conventional farms (CA, n=5) using antibiotic treatments, all of them at pasture. SCC was statistically significantly higher in O (173780) compared to CA (93325) and OA (107152). Milk yield had a significant diluting effect on SCC and differences between groups increased with parities. Stratified analysis of SCC depending on lactation number and % of monthly SCC test with different linear scores (LS) indicated that there is no difference in udder health in the primiparous heifers from the three groups of farms, but it deteriorates in older cows because of chronic infections in O (possibly due to lack of antibiotic use). Our results suggest that the non-use of antibiotics had an effect in udder health leading to higher occurrence of clinical and subclinical mastitis. Therefore, preventive management practices for mastitis control are essential in organic farms.

One of the aims of organic production is to reduce the use of antibiotics in favor of using prophylactic measures as well as alternative therapies (Vaarst *et al.*, 2006). Mastitis is one of the most important production problems in organic and conventional dairy herds and its therapy accounts for a very large proportion of the antibiotic drugs used in the farm. Somatic cell count (SCC), the main indicator of udder health status, has been compared in organic and conventional systems worldwide but antibiotic usage has not been extensively taking into consideration (Bennedsgaard *et al.*, 2010). There are no studies about how lack of antibiotic usage affects udder health status from organic dairy farms in Spain so the aims of this study were to (i) compare udder health (by using the SCC) of organic farms that do not use antibiotics with that of organic and conventional farms that use antibiotic treatments and (ii) evaluate the influence of not using antibiotics on udder health.

Material and Methods

Data on which this paper was based were collected within a big project to evaluate the nutritional and sanitary situation of organic dairy cattle in Spain. All organic dairy farms (n=13) enrolled in Dairy Control Record (DCR) and with willingness to participate in the study were selected and divided according to the antibiotic usage: organic farms not using antibiotics (O, n=6) and organic farms using antibiotics (within the legally permitted number of treatments: OA, n=7). Conventional farms were selected in the neighborhood of the organics on the basis of being grazing farms with similar management practices (CA, n=5). Production and management summaries of the farm groups are presented in Table 1. Detailed data for individual farms is in Supplementary Table S1.

For each farm, SCC (obtained from monthly DCR) was evaluated in all lactating cows during the last complete lactation finished before April 2013 (O, n=154; OA, n=159; CA, n=80). According to Reneau (1986), monthly SCC was transformed in Linear Score (LS) from 1 to 9; LS < 4 was considered as an indicator of healthy udder, from 4 to 6 udders with subclinical mastitis and > 6 clinical mastitis.

Statistical analyses were done using SPSS for Windows (V.20.0). SCC was transformed to base-10 logarithmic scale before statistical analysis. Because cows were from different herds, independent and identically distributed observations could not be assumed, so analyses were carried out with mixed models, in which variable 'herd' was introduced as a random factor. Type of farm (O, OA and CA) and parity number (primiparous heifers, 2nd-3rd parities and ≥4th parities) were introduced as fixed factors to check the effect on SCC and LS thresholds. To state production effect on SCC, individual milk yield was introduced in the analysis as a covariate. Bonferroni post-hoc analyses were performed. The effect of lactation stage on SCC was evaluated by using a repeated-measured ANOVA with type of farm and parity number as fixed main factors and sampling date (1 to 10 monthly controls) as repeated-measures effect.

Results and Discussion

Table 2 shows SCC in organic and conventional farms in our study. Overall, SCC significantly ($p<0.001$) varied regarding type of farm and increased with lactation number. SCC was statistically significantly higher ($F_{2,\ 3920}=9.116$; $p<0.001$) in O (173780) compared to both organic and conventional farms using antibiotics (OA: 107152; CA: 93325). When SCC was compared in organic and conventional farms worldwide, consensus has not been found and only restricted comparisons can be made between studies because data are based on field observations. Even though Hamilton *et*

al. (2006) indicated lower SCC in organic dairy farms, other studies found the opposite to be true (Roesch *et al*., 2007; Rozzi *et al*., 2007) or very little difference between both production systems (Vaarst *et al*. 2006).

Differences between farms using and not using antibiotics increased with the number of parturitions. Considering primiparous heifers alone, significant differences were found between organic (O and OA, lower) and conventional farms (higher), whereas animals with more than 3 parities from group O showed statistically higher SCC than animals receiving antibiotics (OA and CA). Moreover, cows of group O showed higher increase of SCC with the number of parturitions (14.3%, calculated over log transformed data) compared to OA (7.1%) and CA (4.5 %). It is well known that organic farms generally have older animals than conventional farms (Stiglbauer *et al*., 2013) and lactation number have great influence in SCC (Reneau, 1986). In our study, organic farms had far more animals with more than 5 parities (O: 27.2%; OA: 24.8%) than conventional farms (3%). Taking into consideration that there are no differences in lactation number between both organic groups (O and OA), the differences on SCC found between organic farms using and not using antibiotics seem to indicate that sanitary measures to reduce SCC in O are less effective.

When evaluating the percentage of monthly milk samples with different LS thresholds for each complete lactation, it was observed that the percentage of healthy udders in group O was statistically lower (55.4%) compared to CA (77.5%), the group OA (68.0 %) being between them. On the contrary, the percentage of LS indicating subclinical mastitis did not differ between group O (30.5%) and OA (25.4%), even though the percentage of clinical mastitis was statistically lower in group OA (6.61%) compared with group O (14.1%). Taking into consideration the number of parturitions, no differences between groups were observed for primiparous heifers. For the other

parturition categories, the proportion of healthy udders (LS<4) was significantly lower for group O, which, in addition, showed significantly higher incidence of subclinical mastitis (LS: 4-6) and clinical mastitis (LS >6) in the older category. At the beginning of the productive cycle, organic cows not treated with antibiotics had similar or even better health status than the conventional ones. However, with increased parity, the proportion of O group cows with subclinical mastitis increased (and in the higher parities the proportion of those associated to clinical mastitis), presumably as a result of infection chronicity (Villar & López-Alonso, 2016). Older cows have greater risk of chronically higher SCC because of the accumulated risk of getting intrammamary infections that were not totally cured, resulting in a gradual increase in the number of infected quarters (Reneau, 1986) as well as in a decrease of curing rate after several antibiotic treatments (Swinkels *et al*., 2013). The degree in which infection chronicity risk increases and cure rate decreases in herds not treated with antibiotics is not known and deserves more investigation.

Considering the production stage, SCC significantly varied throughout the lactation ($F_{9,414}$= 26.138, p<0.001) and all groups showed similar pattern, increasing from the 3rd month and recording their highest values towards the end of lactation (Figure 1). There is a general consensus that SCC increases during lactation, whilst milk decreases due to a dilution effect, which explain, at least in part, the higher SCC found in organic farms compared to conventional ones, the latter having higher milk yields (Rozzi *et al*., 2007). In fact, milk production showed significant effect on SCC ($F_{1,4211}$= 224.518; p<0.001). However, Cicconi-Hogan *et al.* (2013) explain that the strength of this effect is low and deserves a more thorough investigation.

In the scientific literature there is no agreement about how udder health should be monitored in organic farms. Antibiotic restrictions in the prophylaxis and treatment of

udder infections (especially dry cow treatment) might be a cause of major problems of mastitis (Vaarst *et al*. 2006), but it does not seem to be convincingly demonstrated. Bennesgaard *et al*. (2010) conclude that antibiotic udder treatments may be reduced without apparent negative effects and the control measures for SCC used on organic farms are at least as effective as those on conventional farms in controlling SCC. In this sense, preventive management practices are important in any dairy farm, but especially on organically managed farms, because the availability of products to treat disease is limited (Stiglbauer *et al*., 2013).

In conclusion, SCC was higher in organic farms not using antibiotics compared with organic and conventional farms using antibiotic treatments. Udder health did not differ between organic and conventional farms for primiparous cows, but worsens throughout their productive life in the organics, possibly due to chronic infections related to limited use of antibiotics, showing higher occurrence of both subclinical and clinical mastitis in animals with 4 or more parities in farms not using antibiotic treatments. Although the reduction of antibiotics is needed on organic farms, measures to reduce SCC (especially in older cows) are not as effective as conventional measures, so preventive management practices are essential for mastitis control.

Conflict of interest statement

The authors declare no known conflict of interest.

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155 **References**

156 Bennedsgaard T W, Klaas IC & Vaarst M 2010 Reducing use of antimicrobials —
157 Experiences from an intervention study in organic dairy herds in Denmark. *Livestock*
158 *Science* **131** 183-192

159 Cicconi-Hogan K, Gamroth M, Richert R, Ruegg P, Stiglbauer K & Schukken Y 2013
160 Associations of risk factors with somatic cell count in bulk tank milk on organic and
161 conventional dairy farms in the United States. *Journal of Dairy Science* **96** 3689-3702

162 Hamilton C, Emanuelson U, Forslund K, Hansson I & Ekman T 2006 Mastitis and
163 related management factors in certified organic dairy herds in Sweden *Acta Veterinaria*
164 *Scandinavica* **48** 1-7

165 Reneau J K 1986 Effective use of dairy herd improvement somatic cell counts in
166 mastitis control. *Journal of Dairy Science* **69** 1708-1720

167 Roesch M, Doherr M G, Scharen W, Schallibaum M & Blum J W 2007 Subclinical
168 mastitis in dairy cows in Swiss organic and conventional production systems. *Journal of*
169 *Dairy Research* **74** 86-92

170 Rozzi P, Miglior F & Hand K 2007 A total merit selection index for Ontario organic
171 dairy farmers. *Journal of Dairy Science* **90** 1584-1593

172 Stiglbauer K, Cicconi-Hogan K, Richert R, Schukken Y, Ruegg P & Gamroth M 2013
173 Assessment of herd management on organic and conventional dairy farms in the United
174 States. *Journal of Dairy Science* **96** 1290-1300

175 Swinkels J M, Lam T J G M, Green M J & Bradley A J 2013. Effect of extended
176 cefquinome treatment on clinical persistence or recurrence of environmental clinical
177 mastitis. *Veterinary Journal* **197** 682-687

178 Vaarst M, Bennedsgaard T W, Klaas I, Nissen T B, Thamsborg S M & Ostergaard S
179 2006 Development and daily management of an explicit strategy of non use of
180 antimicrobial drugs in twelve Danish organic dairy herds. *Journal of Dairy Science* **89**
181 1842-1853
182 Villar A, Gradillas G, Fernández C, Rodríguez-Bermúdez R & López-Alonso L 2016
183 Dynamics of mammary infections in organic dairy farms in Northern Spain. *Spanish*
184 *Journal of Agricultural Research* **14** DOI: 10.5424/sjar/2016142-7626
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189 **Table 1.** Summarized details of farms enrolled in this study: Organic farms without
190 antibiotic treatments (O) and organic farms (OA) and conventional farms (CA) using
191 antibiotic treatments. Data are presented as arithmetic mean (herd size, nº of
192 parturitions, milk yield, calving interval) and median (nº of treatments/cow/year) and
193 range.

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	O (n=6)	OA (n=7)	CA (n=5)
Predominant breed	Holstein Friesian[1]	Holstein Friesian[1]	Holstein Friesian
Type of farm	Free stall (66.7%) Tie stall barn (33.3%)	Free stall barn	Free stall barn
Herd size	26 (22-37)	29 (16-48)	26 (18-32)
Nº of parturitions	3.81 (1-10)	3.83 (1-12)	2.60 (1-8)
Calving interval (days)	432 (411-450)	421 (409-434)	381 (361-413)
Milk yield (L) per cow/year	5517 (5000-6300)	6562 (5600-8452)	8650 (8062-9062)
Forage intake (% total DMI)	78.3	78.9	78.9
Pasture (% of forage intake)	77.3	43.2	52.2
Udder hygiene[2]	66.7%	71.4%	100%
Dry cow therapy	None	Selective[3]	Blanket
Mastitis treatment/cow/year			
Clinical	0.04 (0.00-0.50)	0.05 (0.00-0.19)	0.04 (0.01-0.15)
Subclinical	0.00 (0.00-0.00)	0.00 (0.00-0.00)	0.30 (0.22-0.55)

195 [1]OH 4 farms with breed diversity (36 crosses and 8 Brown Swiss). OA: 5 farms with breed diversity (26
196 crosses, 20 Brown Swiss).
197 [2]pre-dipping and post-dipping
198 [3] mean: 31% cows (range:12-33%)

199 **Table 2.** Comparison of somatic cell count (SCC) and proportion of monthly samples with different linear scores between organic farms without
200 antibiotic treatments (O), organic farms with antibiotic treatments (OA) and conventional farms (CA). Different superscript letters in the same
201 row indicate statistically significantly differences between different types of farms whereas different superscript numbers in the same column
202 indicate statistically significantly differences between number of parities.

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		O	OA	CA
SCC (*10^3)				
All cows	N	1540	1890	800
	Geometric mean	174^{a}	107^{b}	93^{b}
	Range	5-15135	6-14125	6-11749
Primiparous heifer	N	350	340	260
	Geometric mean	66$^{b.1}$	58$^{b.1}$	75$^{a.1}$
	Range	7-2511	6-4466	6-11748
Cows 2-3 lactations	N	520	650	330
	Geometric mean	154$^{a.2}$	109$^{b.2}$	87$^{c.1}$
	Range	5-7943	6-4073	7-10471
Cows >3 lactations	N	670	900	210
	Geometric mean	323$^{a.3}$	129$^{b.3}$	126$^{b.2}$
	Range	13-60255	6-14125	13-10233
Linear score (%)				
<4		55.39^{c}	67.99^{b}	77.50^{a}
4-6		30.52^{a}	25.40^{a}	13.87^{b}
>6		14.09^{a}	6.61^{b}	8.63^{ab}

Figure Captions

Figure 1. Analysis of SCC in organic farms without antibiotic treatments (O), organic farms with antibiotic treatments (OA) and conventional farms (CA) considering the production stage by using a repeated-measured ANOVA.