ELSEVIER

Livestock Production Science 80 (2003) 121–131

LIVESTOCK PRODUCTION SCIENCE

www.elsevier.com/locate/livprodsci

Eleven years of organic dairy production in Denmark: herd health and production related to time of conversion and compared to conventional production

T.W. Bennedsgaard[a,*], S.M. Thamsborg[b], M. Vaarst[c], C. Enevoldsen[d]

[a]*Department of Animal Husbandry and Animal Health, The Royal Veterinary and Agricultural University, Groennegaardsvej 2, DK-1870 Frederiksberg C, Denmark*

[b]*Department of Veterinary Microbiology, RVAU, Dyrlægevej 100, DK-1870 Frederiksberg C, Denmark*

[c]*DIAS, PO Box 50, DK-8830 Tjele, Denmark*

[d]*Department of Clinical Studies, RVAU, Dyrlægevej 88, DK-1870 Frederiksberg C, Denmark*

Abstract

This paper focuses on the changes in production, herd health and veterinary treatments in Danish organic dairy herds over ~11 years based on historic data from herds converted to organic milk production before 1990 (old organic herds) compared to herds converted in 1995 and 1999–2000 and herds that are still conventional. Herd size, milk production, the shape of the lactation curve, somatic cell counts and veterinary treatments for mastitis, retained placenta and ketosis were compared over time and between herd groups. The old organic herds differed from the other three herd groups by having lower milk production per cow, lower somatic cell counts and fewer treatments for mastitis. Herds converted in 1995 and 1999–2000 were comparable to the conventional herds before conversion for all analyzed parameters. However, herd size was larger than both the older organic herds and the conventional herds after conversion. Production was ~2 kg energy corrected milk lower per cow per day than before conversion and compared to the conventional herds. In the herds converted in 1999–2000 little difference could be seen in relation to udder health after conversion when compared to conventional herds. The organic herds had fewer treatments for retained placenta and ketosis than the conventional herds. The shape of the lactation curves changed over the 11-year period with better persistency from day 60 to day 305 in all herd groups except for the old organic herds, which had the best persistency in 1990.

Keywords: ; Organic farming; Dairy; Herd health; Milk production

1. Introduction

The number of organic dairy herds in Denmark increased dramatically during the 1990s from ~70 herds in 1989 to 870 herds in 2000; a change from 0.3 to 8.4% of the total number of dairy herds. Research in organic farming and the number of agricultural advisers with special knowledge of organic farming have increased in the same period. In contrast, local veterinarians still provide herd

*Corresponding author. Tel.: +45-3528-3027; fax: +45-3528-3055.

E-mail address: twb@kvl.dk (T.W. Bennedsgaard).

0301-6226/02/$ – see front matter © 2002 Published by Elsevier Science B.V.
doi:10.1016/S0301-6226(02)00312-3

health services and perform disease treatments without specialization in organic farming.

Organic milk production is based on a combination of general principles and detailed rules. Since the introduction of national certification of organic farms by the Danish Government in 1988, the specific rules have been changed several times. An important issue right from the beginning was restrictions on the use of antibiotics in dairy cows: extended withdrawal periods and prohibition of the prophylactic use of antibiotics and treatments had to be implemented by the local veterinarian. The introduction of national regulations and subsidies for organic farming in Denmark were followed by the introduction of organic products, especially drinking milk, in all major supermarkets at reduced prices. The result has been a market share of 22% for drinking milk with 10% of milk production being organic since 2000.

Early studies in 1990–1993 in 14 Danish organic herds (constituting 20% of all organic dairy herds in Denmark in 1989) concluded that the use of antibiotic treatment for mastitis was low in the organic dairy herds compared to conventional herds whereas bulk somatic cell counts were at the same or a lower level. Proportion of cows treated for mastitis varied considerably with a median of treatment in 9% of the lactations (3–23%, 10th/90th percentiles) compared to 31% (7–52%) in a comparable group of conventional herds (Vaarst, 1995; Vaarst and Enevoldsen, 1997). Comparison of lactation curves in the same group of organic and conventional herds showed that the peak milk yield was lower in the organic herds but persistency of yield from week 4 to week 36 post partum was better. The resulting difference in 305-day milk production was not significant, when accounting for breed and housing as explanatory variables (Kristensen and Kristensen, 1998).

In Sweden, 26 organic herds that converted before 1995 were compared to data from 1102 conventional herds based on data from 1997 to 1998 (Hamilton et al., 2002). Herd size was found to be the same in the two groups whereas production was 18% lower (7572 and 6313 kg per cow year) in the organic herds. Mean incidence of veterinary treatment of mastitis and retained placenta were found to be significantly lower in the organic herds when corrected for herd size, yield, breed and lactation number. Treatment for ketosis was at a very low level in the organic herds, though not significantly different from the conventional herds due to large variation between herds.

Other studies have indicated that the use of veterinary medicine is lower in organic herds. However, udder health in organic herds assessed by individual cow or bulk tank somatic cell counts is not different from conventional herds (Hovi and Roderick, 2000; Weller and Bowling, 2000). In Norway, cows in conventional herds were found to be treated for mastitis about three times more often than cows in organic herds converted before 1995 (odds ratio 0.38). Somatic cell counts were at the same level in the two groups (Hardeng and Edge, 2001).

In all studies mentioned considerable variation in udder health was found between herds as well as between years. The main reason might be that the udder health and also the choice of using antibiotics for an intramammary infection are highly related to the management of the herd (Bartlett et al., 1992; Barkema et al., 1999). Differences between organic and conventional herds in somatic cell counts and use of disease treatment may be a result of the policy and capability of the individual herd manager irrespective of production system or a result of general differences between the herd groups as a result of the organic regulation and production principles.

The objectives of this study were: (1) to describe changes in milk production and selected indicators of herd health after the time of conversion; and (2) to describe differences between organic herds converted at different times and conventional herds. This approach was used to show if the organic herds differed from the conventional herds before conversion and to give an indication of whether the herds converted at different times experienced the same changes in the analyzed parameters after conversion.

2. Material and methods

2.1. Data collection

Herds were selected mainly from the southern and western part of Denmark containing 25% of the

Danish dairy herds. A total of 12 herds involved in research projects from 1990 to 1993 (Vaarst and Kristensen, 1993) were specially invited to participate and all accepted. These herds were originally selected from all over Denmark and represented ~20% of the total number of organic dairy herds at that time. The conventional herds and herds converting in 1999–2000 were selected by inviting all herds in an area to participate in a number of research projects in 1999. Selection of the herds converting before 1990 and in 1995 was done by inviting all the herds converted before 1990 and every other herds converting in 1995 in a larger area overlapping the area of the conventional herds to participate in different research projects in 1998–1999. All research projects were related to herd health and use of veterinary medicine. Of the herds asked to participate, 40–50% accepted the invitation. Herds that had ceased milk production before 2001 or which had low level of disease reporting to the database, compared to registrations on the farm based on control of 1999–2000 data, were excluded.

Data on milk production were available from 29 herds converted before 1990, 35 herds converted in 1995, 18 herds converted in 1999 or 2000 and 99 conventional herds (Table 1). Data on disease treatments were available from 1994 to 2002 in 24 herds converted in 1990, 24 herds converted in 1995, 15 herds converted in 1999–2000 and 75 conventional herds. In 13 of the herds converted before 1990, data on disease treatment were also available from 1991 to 1994. Of these 13 herds, 12 participated in the 1990–1993 study. The main reason for exclusion of herds for the evaluation of disease treatments was start of registration later than 1994. Data has been reported to and stored in the Danish cattle database continuously. Data on culling, reproduction, milk yield, somatic cell counts (SCC) and disease treatments were available at cow level.

2.2. Data handling and statistical analysis

Longevity of cows was calculated as mean calving number for each year. Jersey cows stayed on average 0.36 lactations longer in the herds, which is comparable with the estimate of 0.3 in a larger Danish study (Anon, 1996). The herd averages were corrected for the Jersey breed by subtracting 0.36 from the herd average before calculating statistical difference. The data before 1993 are not shown because of a high number of missing registrations of calving number for cows introduced to the herd before 1990 (2% missing compared to 0.2% in later years).

Production level was assessed by estimation of individual cow lactation curves using a two-piece linear regression model with intercept (expected peak) at day 60 after calving (Enevoldsen et al., 2000). Cows with at least one milk record before day 60 and last test day later than day 180 were included in the analysis. Expected 305-day yield, peak yield at day 60 and reduction in milk yield from day 60 to day 305 (persistency) were calculated for all included cows to adjust for culling between day 180 and day 305. Milk production was calculated as energy corrected milk (ECM) (Sjaunja et al., 1990). Significance of differences between herd groups were calculated using a mixed linear model in PROC MIXED in SAS 8.2, with Jersey breed, herd group

Table 1
Study herds and total dairy herds in Denmark in 1999

Herd group	Study population		Total number of dairy farms in Denmark	
	Herds	Cows	Herds	Cows
Organic farms				
Converted before 1990	29	2405	57	NA
Converted in 1995	35	3298	167	NA
Converted in 1999–2000	18	1767	441[a]	NA
All organic farms	82	7470	870[a]	66 910
Conventional farms	99	8197	11 162	640 194

[a] Herds converted in 2000 started conversion in 1999.

and year within herd group as fixed effects and herd as random effect. Average milk production per cow per herd for each year as ECM was calculated and used for comparison of milk yield between herd groups. The production of cows of Jersey breed were multiplied by 1.11 before calculations based on data of the national average production of all Holstein Friesian and Jersey cows in Denmark from 1994 to 2001.

Theoretical bulk tank somatic cell count was the product of individual SCC and milk yield divided by the sum of milk yield at test day. Herd size was the number of cows on test days. The herd means were calculated for each year. Tests of statistical significance of differences between herd groups were performed using a mixed linear model with herd group and year within herd group as fixed effects and herd as random effect using PROC MIXED in SAS 8.2.

Incidence of mastitis treatment as registered in the Danish cattle database was calculated per month. The herd means were calculated for each year. Treatments within 10 days from last treatment were excluded.

Statistical significance was tested after normalization of the data by using normal scores based on the rank using the Bloom option in PROC RANK in SAS 8.2. Treatments for retained placenta were calculated as proportion of calvings for each year. Treatments for ketosis before day 60 were calculated for each year as the proportion of calvings. Because of skewness of the data for retained placenta and ketosis as a result of a very low frequency in all herd groups statistical significance was calculated using the proportion of herds with at least one treatment in a year using logistic regression in PROC GENMOD in SAS 8.2 with herd group, year within group and Jersey breed as explanatory variables. Analysis on the incidence of retained placenta and ketosis was only done for parity 3 because a large variation with higher parity was found and it was not possible to determine whether or not these differences were a result of different culling policies in the different herd groups. Differences in culling rate, calving interval, age at first calving, choice of sires for artificial insemination and incidence of milk fever where also explored, but no significant differences were found. The results of these calculations are not included in this paper.

3. Results

Changes in herd size, production, somatic cell counts and veterinary treatments are summarized for the years 1992, 1994, 1996, 1998 and 2001 in Tables 2–4 and selected variables are plotted in Figs. 1–4.

3.1. Herd structure

The four herd groups did not differ significantly with respect to herd size during 1992–1998. The variation in herd size was large with the 10th and 90th percentiles ranging from 37 to 173 in 2001. The spread in herd size was larger in 2001 than in 1992.

The cows in the herds converted before 1990 were older compared to the conventional herds in all years. The mean calving number of the cows in the herds converted in 1995 and in 1999–2000 did not differ significantly before conversion. After conversion the cows in the herds converted in 1995 were getting older, and the average calving number differed significantly ($P < 0.05$) from the conventional herds and the herds converted in 1999–2000 from 1999–2001 (Table 2).

3.2. Daily milk production

The average daily milk production was significantly lower in the herds converted before 1990 than all other herd groups throughout the period (Table 2).

The herds converted in 1995 had a significantly ($P < 0.05$) higher milk production than the conventional herds in 1994 just before conversion, except for 1992. After conversion the production in the herd groups converted in 1995 and in 1999–2000 had a significantly lower milk production than the conventional herds. The difference in milk production was ~2 kg per day in the herds converted in 1995 and 1999–2000 and ~3.7 kg per day for the herds converted before 1990 compared to the conventional herds.

3.2.1. Somatic cell counts

The calculated bulk tank somatic cell counts (CBSCC) were decreasing in all herds groups from 1991 to 1996 (Table 2; Fig. 1). The CBSCC were significantly lower in the herds converted before 1990 than in all other herd groups except in 1998.

Table 2
Herd structure and production data for 82 organic herds and 99 conventional herds in Denmark

Variable	Time of conversion	No. herds	1992	1994	1996	1998	2001
Herd size (no. cows)	Before 1990	29	64 (33–109)	71 (35–128)	78 (38–151)	81 (38–146)	89 (37–152)
	1995	35	68 (41–103)	73 (45–106)	80 (51–133)	92 (56–162)	104 (59–173)
	1999–2000	18	66 (40–90)	73 (41–113)	79 (44–123)	87 (45–131)	113 (65–155)
	Conventional	99	66 (41–91)	71 (45–103)	77 (47–111)	84 (52–130)	93 (58–137)
Average calving number	Before 1990	29		2.4[a] (2.1–2.7)	2.5[a] (2.1–2.9)	2.5[a] (2.1–2.8)	2.4[a] (2.0–2.8)
	1995	35		2.2[b] (1.8–2.6)	2.3[b] (2.0–2.5)	2.4[b] (2.1–2.7)	2.5[a] (2.3–2.7)
	1999–2000	18		2.1[b] (1.9–2.9)	2.2[b] (1.9–2.7)	2.2[b] (2.0–2.6)	2.2[b] (1.9–2.6)
	Conventional	99		2.2[b] (1.9–2.5)	2.3[b] (2.0–2.7)	2.3[b] (2.0–2.6)	2.3[b] (1.9–2.6)
ECM, daily (kg)	Before 1990	29	20.9[a] (17.9–23.9)	21.0[a] (17.9–24.4)	20.7[a] (18.1–23.3)	21.4[a] (19–24.1)	22.1[a] (18.6–25.2)
	1995	35	22.4[b] (20.3–25.1)	23.3[b] (20.2–25.7)	22.4[b] (19.4–25.1)	22.6[b] (20.1–24.8)	23.7[b] (21.2–26.4)
	1999–2000	18	22.4[b] (21–24.3)	23.0[b,c] (19.9–25.6)	23.5[c] (19.8–25.9)	24.2[c] (20.8–27.2)	24.2[b] (21.4–27.1)
	Conventional	99	22.3[c] (20–24.8)	22.5[c] (20–25.4)	23.4[c] (20.3–26.1)	24.2[c] (21.4–27.3)	25.8[c] (22.7–28.9)
Calculated bulk somatic cell count ($\times 1000$/ml)	Before 1990	29	320[a] (220–430)	290[a] (180–390)	270[a] (150–360)	290[a] (190–390)	270[a] (180–380)
	1995	35	410[b] (300–490)	330[b] (240–390)	310[b] (240–370)	320[b] (243–440)	320[b] (240–400)
	1999–2000	18	370[c] (250–530)	320[b] (210–420)	310[b] (240–390)	290[a,b] (190–410)	330[b] (240–420)
	Conventional	99	360[c] (250–490)	330[b] (230–410)	310[b] (220–400)	290[a] (210–380)	310[b] (190–460)

Herd averages and 10th and 90th percentiles.
[a,b,c] Values within one column with different superscripts differ significantly ($P < 0.05$).

The herds converted in 1995 had significantly ($P < 0.05$) higher CBSCC in 1992 than the other herd groups.

3.3. Characteristics of the lactation curves

When using the estimated lactation curves, it was found that the herds converted before 1990 had significantly ($P < 0.05$) lower peak yield and 305-day production than the other three herd groups in all years in both first and third lactation (Table 3). In 1992 and 1993, the persistency was better in the herds converted before 1990 compared to the other herd groups, but in 1996, 1997, 1999 and 2000 the difference was not statistical significant compared to the conventional herds. In 2001, the conventional herds and the herds converted in 1999–2000 had significantly ($P < 0.05$) better persistency than the herds converted before 1990.

The conventional herds had significantly ($P < 0.05$) higher peak yield and estimated 305-day production in all years compared to the organic herds. The herds converted in 1995 and 1999–2000 did not differ significantly from the conventional herds before conversion except for a better persistency in first lactation in 1994 and in third lactation

Table 3
Parameters of estimated 305-day lactation curve for cows with at least 180 days in milk

Variable	Time of conversion	No. herds	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
First lactation												
Peak yield,	Before 1990	29	20.4^{a}	20.6^{a}	20.1^{a}	20.1^{a}	20.1^{a}	20.5^{a}	21.0^{a}	21.3^{a}	21.8^{a}	21.6^{a}
day 60	1995	35	23.2^{b}	24.2^{b}	23.6^{b}	23.2^{b}	22.1^{b}	22.0^{b}	22.4^{b}	22.1^{a,b}	23.0^{b}	23.1^{b}
(kg ECM)	1999–2000	18	22.9^{b}	23.3^{b}	23.0^{c}	22.7^{b}	23.3^{c}	23.7^{c}	24.4^{c}	23.0^{b}	23.1^{b}	23.7^{b}
	Conventional	99	23.4^{b}	23.5^{b}	23.4^{b,c}	23.3^{b}	23.8^{c}	24.2^{c}	24.5^{c}	24.7^{c}	25.8^{c}	26.0^{c}
Persistency	Before 1990	29	−17^{a}	−14^{a}	−18^{a}	−16^{a}	−17^{a,b}	−15^{a,b}	−14^{a}	−12	−13^{a,b}	−17^{a}
(percent change	1995	35	−21^{b}	−22^{b}	−22^{b}	−19^{b}	−16^{a}	−14^{a}	−15^{a}	−11	−12^{a}	−14^{a}
in kg ECM, day	1999–2000	18	−21^{b}	−20^{b}	−18^{a}	−16^{a}	−16^{a,b}	−15^{a,b}	−16^{a,b}	−12	−7^{c}	−10^{b}
60 to day 305)	Conventional	99	−21^{b}	−22^{b}	−21^{b}	−18^{a,b}	−18^{b}	−17^{b}	−18^{b}	−13	−15^{a,b}	−11^{b}
305 Days'	Before 1990	29	5720^{a}	5840^{a}	5620^{a}	5640^{a}	5640^{a}	5780^{a}	5970^{a}	6040^{a}	6190^{a}	6040^{a}
production	1995	35	6430^{b}	6640^{b}	6500^{b}	6440^{b}	6250^{b}	6240^{b}	6340^{b}	6350^{b}	6580^{b}	6570^{b}
(kg ECM)	1999–2000	18	6370^{b}	6470^{b}	6400^{b}	6430^{b}	6600^{c}	6730^{c}	6900^{c}	6600^{b}	6750^{b}	6850^{b}
	Conventional	99	6450^{b}	6450^{b}	6460^{b}	6530^{b}	6670^{c}	6800^{c}	6850^{c}	7050^{c}	7310^{c}	7470^{c}
Third lactation												
Peak yield,	Before 1990	29	27.2^{a}	26.9^{a}	26.5^{a}	26.4^{a}	26.8^{a}	26.8^{a}	26.7^{a}	27.5^{a}	28.1^{a}	28.5^{a}
day 60	1995	35	29.8^{b}	30.8^{b}	30.4^{b}	30.2^{b}	29.0^{b}	28.4^{b}	28.9^{b}	29.4^{b}	30.2^{b}	30.7^{b}
(kg ECM)	1999–2000	18	30.0^{b}	29.8^{b}	30.0^{b}	30.5^{b}	31.2^{c}	29.8^{c}	31.9^{c}	29.8^{b}	30.5^{b}	31.1^{b}
	Conventional	99	30.0^{b}	30.0^{b}	30.0^{b}	30.2^{b}	31.0^{c}	31.1^{d}	31.8^{c}	32.1^{c}	33.8^{c}	33.5^{c}
Persistency	Before 1990	29	−41^{a}	−38^{a}	−40^{a}	−37^{a}	−40^{a,b}	−33^{a}	−34^{a}	−35	−34^{a}	−41^{a}
(percent change	1995	35	−46^{b}	−49^{b}	−44^{b,c}	−42^{b}	−39^{a}	−37^{a,b}	−36^{a}	−33	−33^{a}	−36^{b}
in kg ECM, day	1999–2000	18	−47^{b}	−48^{b}	−41^{a,b}	−41^{a,b}	−38^{a}	−35^{a}	−41^{b}	−36	−33^{a}	−35^{b}
60 to day 305)	Conventional	99	−47^{b}	−49^{b}	−47^{b}	−45^{b}	−43^{b}	−40^{b}	−40^{b}	−34	−38^{b}	−36^{b}
305 Days'	Before 1990	29	6920^{a}	6920^{a}	6720^{a}	6810^{a}	6820^{a}	7010^{a}	6990^{a}	7150^{a}	7320^{a}	7190^{a}
production	1995	35	7400^{b}	7550^{b}	7600^{b}	7650^{b}	7410^{b}	7330^{b}	7530^{b}	7760^{b}	7970^{b}	7990^{b}
(kg ECM)	1999–2000	18	7420^{b}	7340^{b}	7590^{b}	7760^{b}	8020^{c}	7790^{c}	8110^{c}	7770^{b}	8030^{b}	8090^{b}
	Conventional	99	7430^{b}	7340^{b}	7420^{b}	7550^{b}	7810^{c}	7950^{c}	8110^{c}	8420^{c}	8700^{c}	8650^{c}

Peak yield (day 60), persistency from day 60 to day 305 after calving and estimated 305-day production. Herd averages per year.
^{a,b,c,d} Values within one column with different superscripts differ significantly ($P < 0.05$).

in 1996 and 1997 in the herds converted in 1999–2000.

3.4. Veterinary treatments

The incidence of mastitis treatment is shown in Fig. 2 (medians) and Table 4 (means). The organic herds converted before 1990 showed a constantly low level compared to the other herd groups. The incidence was significantly ($P < 0.05$) lower than in the conventional herds and than in the herds converted in 1995 and 1999–2000 before conversion, and in 1998 and 2001 also compared to the herds converted in 1995. The herds converted in 1995 had a lower level of mastitis treatment at 0.56 treatments per cow-year in 1994 before conversion compared to the conventional herds in the study. After conversion the incidence dropped to 0.4 in 1996 but stabilized at ~0.5 from 1997 through 2001.

The incidence of treatment for retained placenta in parity 3 was at a lower level in the herds converted before 1990 and the herds converted in 1995 after conversion compared to the conventional herds. In the herds converted in 1999–2000 the lowest incidence of retained placenta was found in 2001 at a level comparable to the other organic herds, but this might be by chance. (Table 4; Fig. 3).

The proportion of herds with at least one treatment for ketosis per year showed a marked decrease after conversion to organic farming for the herds con-

Table 4
Veterinary treatments from the Danish cattle database

Variable	Time of conversion of organic farms	No. herds	1994	1995	1996	1997	1998	1999	2000	2001
Mastitis treatments per cow year	Before 1990	24	0.34^{a}	0.32^{a}	0.29^{a}	0.33^{a}	0.32^{a}	0.40^{a}	0.38^{a}	0.33^{a}
	1995	24	$0.56^{a,b}$	$0.54^{a,b}$	$0.40^{a,b}$	0.48^{b}	0.50^{b}	$0.52^{a,b}$	$0.47^{a,b}$	0.50^{b}
	1999–2000	15	$0.63^{b,c}$	$0.56^{b,c}$	$0.50^{b,c}$	0.47^{b}	0.56^{b}	$0.50^{a,b}$	$0.47^{a,b}$	0.46^{b}
	Conventional	75	0.69^{c}	0.66^{c}	0.59^{c}	0.60^{b}	0.60^{b}	0.58^{b}	0.58^{b}	0.59^{b}
Retained placenta (percent of calvings) (parity 3)	Before 1990	24	6.2^{a}	6.6	4.8^{a}	$4.6^{a,b}$	4.3^{a}	4.0^{a}	4.0^{a}	6.2^{a}
	1995	24	$7.2^{a,b}$	7.7	7.7^{b}	3.2^{a}	$5.2^{a,b}$	6.1^{a}	4.1^{a}	6.1^{a}
	1999–2000	15	10.3^{b}	8.6	10.3^{b}	$9.1^{b,c}$	$7.2^{b,c}$	11.5^{b}	8.9^{b}	6.3^{a}
	Conventional	75	9.1^{b}	10.3	10.4^{b}	10.7^{c}	9.9^{c}	10.0^{b}	9.8^{b}	10.7^{b}
Ketosis (percent of calvings before day 60) (parity 3)	Before 1990	24	1.4	0.3^{a}	$0.3^{a,b}$	$0.3^{a,b}$	0.4^{a}	0.3^{a}	0.4^{a}	0.5^{a}
	1995	24	2.5	0.0^{a}	0.0^{a}	$0.1^{a,b}$	0.0^{a}	0.1^{a}	0.3^{a}	0.2^{a}
	1999–2000	15	2.8	1.5^{b}	1.9^{b}	$1.7^{b,c}$	0.2^{a}	$1.2^{a,b}$	0.4^{a}	0.3^{a}
	Conventional	75	2.1	1.9^{b}	1.6^{c}	1.6^{c}	2.4^{b}	1.9^{b}	1.3^{b}	2.1^{b}

Only herds with registrations from 1994 to 2001 are included.
[a,b,c] Values within one column with different superscripts differ significantly ($P < 0.05$).

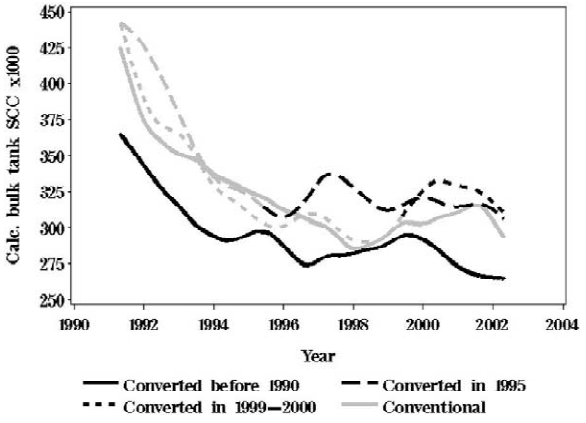

Fig. 1. Calculated bulk tank somatic cell count for herds converting at different times and conventional herds. Converted before 1990: solid line, black; converted in 1995: broken line, grey/black; converted in 1999–2000: dotted line, grey/black; conventional: solid line, grey. Lines are grey for conventional herds and black for organic herds.

verted in 1995 (Table 4; Fig. 4). The number of herds converted in 1999–2000 with disease registration is so low that the high variability in this group might be by chance, but both the incidence and the proportion of herds with treated cows is on a level comparable with the other organic herds from 1998.

4. Discussion

4.1. Herd structure

In 2001 the herds having converted in 1995 and 1999–2000 are characterized by larger herd size, larger milk production and higher treatment frequencies for mastitis than the older organic herds. In general the organic dairy herds in Denmark are ~20% larger than the conventional herds (Enemark and Kjeldsen, 1999). The variation in herd size is larger in the converted herds than the conventional herds, indicating a marked expansion in a minor proportion of herds. Often the conversion to organic production is combined with the construction of new buildings with loose housing. The reasons for conversion have been discussed with a group of Danish dairy farmers who converted in 1996–1997. Several farmers in the group stressed that they saw the conversion to organic farming as a way of ensuring a future in milk production on the farm (Vaarst, 2000).

The increase in the age of the cows after conversion in the herds converted in 1995 and the constantly higher age of the cows in the herds converted before 1990 might be a result of the lower production level, the lower level of disease treatments and for the herds converted before 1990, the lower somatic cell counts. It might to some extent also be a

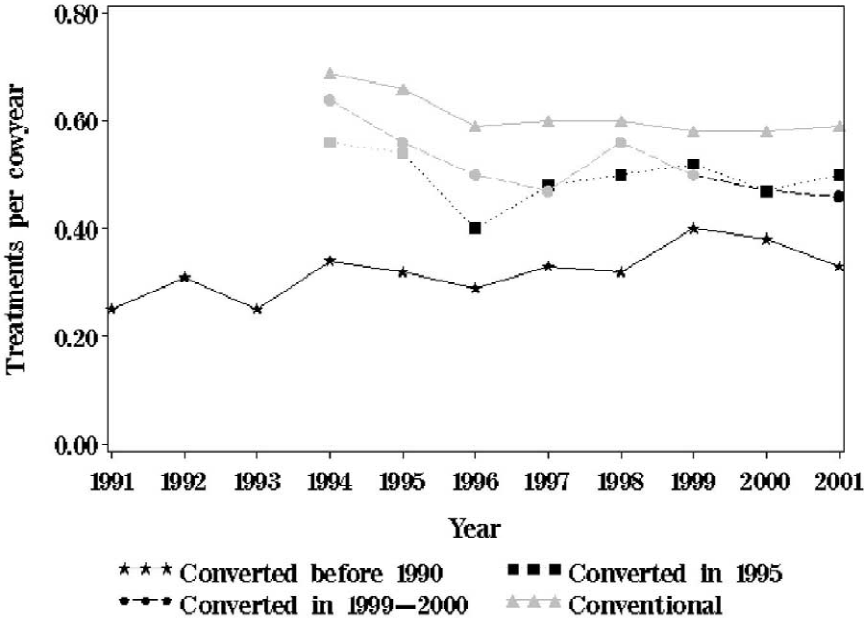

Fig. 2. Mastitis treatments per cow year. Mean of herd means. Herds converted before 1990: star; herds converted in 1995: square; herds converted in 1999–2000: dot; conventional herds: triangle. Symbols are grey for conventional herds and black for organic herds.

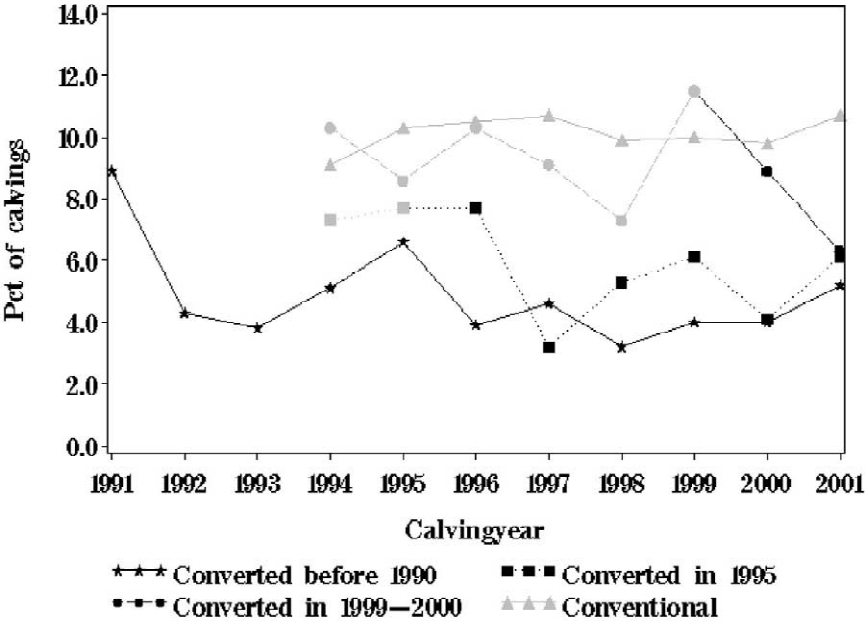

Fig. 3. Herd means of treatments for retained placenta. Percent of calvings followed by veterinary treatment for retained placenta before day 5. Herds converted before 1990: star; herds converted in 1995: square; herds converted in 1999–2000: dot; conventional herds: triangle. Symbols are grey for conventional herds and black for organic herds.

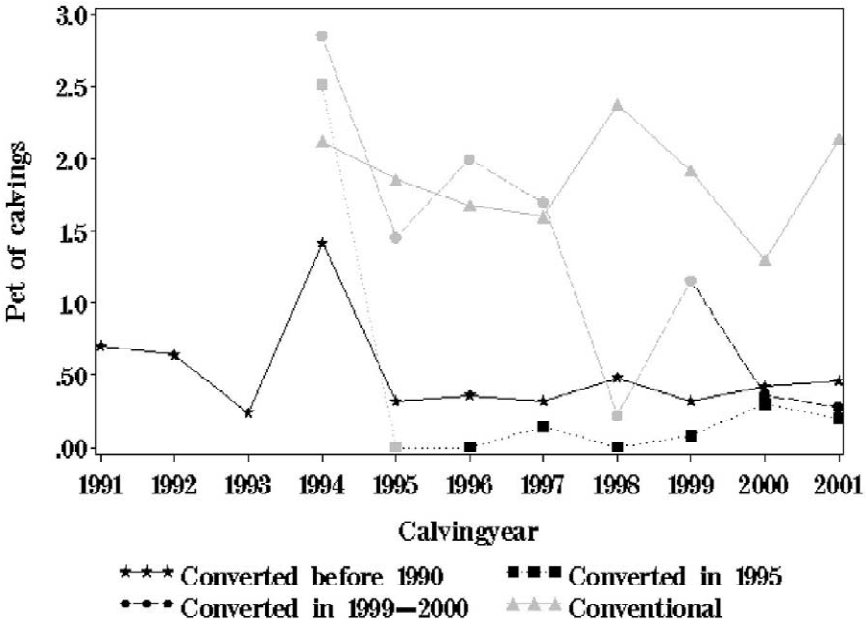

Fig. 4. Herd means of treatments for ketosis. Proportion of cows in third lactation treated by the veterinarian within 60 days after calving. Herds converted before 1990: star; herds converted in 1995: square; herds converted in 1999–2000: dot; conventional herds: triangle. Symbols are grey for conventional herds and black for organic herds.

result of the increasing herd size in the herds converted in 1995 and 1999–2000. Kristensen and Kristensen (1998) did not find any difference in average calving number in the 1990–1993 study in 18 conventional and 13 organic herds. This might be a result of the herds not being representative since the average calving number of the cows in the conventional herds was 0.2 higher than in this study (1990–1993 data compared to 1993). Furthermore, the statistical analysis included a correction of the average calving number for Jersey breed of -0.56 which is far more than the estimate of 0.3 from a larger Danish study (Anon, 1996). The large correction for Jersey breed might have resulted in an underestimation of the average calving number in the organic herds since the organic herds had the highest proportion of Jersey cows.

4.2. Milk production

The difference in persistency of milk production between the organic and the conventional herds has diminished from 1996 in both first and third lactations, the general trend being better persistency in all herd groups. The better persistency in the organic herds in the early 1990s was explained by the production level, larger amount of roughage and lower disease frequency (Kristensen and Kristensen, 1998). These authors also stated that the feeding strategy was more important for the shape of the lactation curve than the amount of energy. Our data show the same difference between organic and conventional herds in the early 1990s and furthermore the data show that the persistency has been improved despite higher production levels in all herd groups. This might be a result of changes in feeding practice in both organic and conventional herds.

The lower average production and peak yield in the herds converted before 1990 might be a result of less use of concentrate than in the newer organic herds. Until late 2001 a large amount of the concentrate in organic herds has been conventional feedstuff, often rapeseed products. From 2002 and in some herds from 2001, only certified organic feed was allowed by the dairies. This might explain the stagnation in yield in 2001 in the herds converted

before 1990 and in 1995.

4.3. Somatic cell counts

In all herd groups a marked drop in somatic cell counts is seen from 1992 to 1996.

Measurement of individual cow somatic cell counts started in most herds in 1990 or 1991. The drop in the CBSCC might be a result of information on individual SCC combined with reduced milk price from March 1993 if the somatic cell count of the bulk milk was more than 300.000, and a ban on milk delivery when the rolling geometric average was higher than 400.000 for a prolonged period. In the herds converted in 1995 and in 1999–2000 there is a tendency towards a higher CBSCC in the first 1 or 2 years after conversion. In the herds converted in 1995 the treatment frequency for mastitis was lower in the 1st year after conversion although the difference was not statistical significant ($P = 0.14$). The combination of lower treatment frequency and higher CBSCC could be a result of changes in treatment policy in trying to cure mastitis without using antibiotics.

The old organic herds having converted before 1990 had a persistently lower CBSCC compared to the other herd groups, though the difference has been reduced as a result of the declining SCC in the other herd groups. The difference might be explained by the differences in herd size and milk production seen in this study, which might be the result of different management priorities of the farmers. It is interesting that the herds converted before 1990 have both the lowest treatment frequency and the lowest CBSCC.

4.4. Veterinary treatments

In general registration of veterinary treatments is a questionable indicator of herd health. The main problem is that registration only occurs when the farmers calls the vet. Both mastitis and ketosis are diseases with a high proportion of subclinical cases, and the farmer's threshold for treatment will influence the resulting treatment rate significantly. Nor does the character of the data allow conclusions regarding the total amount of antibiotics used in the herds. In Denmark conventional herds have an official herd health advice contract approved by the veterinary authorities and including mandatory monthly herd visits by the veterinarian: the farmer are allowed to get antibiotics for follow-up treatments of cows for which the veterinarian has initiated the treatment. Registrations in the herds converted in 1999–2001 showed that the average period of mastitis treatment was reduced from 2–3 days to 1–1.5 days after conversion (Vaarst et al., 2003).

The differences seen between the organic herds converted in 1990 and the newer organic herds in relation to the use veterinary treatments might be a question of different management priorities of the farmers related to the farmer's perception of good farming practice and the idea of organic farming. A strong demand from the market in the 1990s combined with high prices for organic milk and financial subsidies might have attracted farmers with priorities different from those of the farmers of the herds converted before 1990, when it was not always possible to get premium prices for organic products. These theoretical considerations are strengthened by the result of an interview survey in the herds converted in 1999–2000, where the farmers said that they did not see changes in mastitis treatment as a result of being organic (Vaarst et al., 2003). Similar changes in organic farmers' attitudes with less emphasis on ideology/principles have been noted in other countries (Hayton, 1999).

4.5. Perspectives of Danish organic dairy production

Herds converted before 1990, some of which had been organic or biodynamic since the 1960s or 1970s, seem to differ from the newly converted organic herds with lower production, lower somatic cell counts and less use of antibiotic treatment for mastitis. The herds converted in 1999–2000 are comparable with the herds converted in 1995 with regard to herd size, milk production, somatic cell counts and mastitis treatment. In the herds converted in 1999–2000 little difference can be seen in relation to udder health after conversion when compared to conventional herds, whereas milk production was reduced immediately after conversion. The differences between the organic herds converted before 1990 which make up only 10% of the organic herds

in Denmark and the herds converted in 1995 or later, which make up ~80%, and the small differences in mastitis treatment and somatic cell count between the conventional herds and the newly converted organic herds raises the question whether regulations of organic production are sufficient to ensure a noticeable difference in herd health between organic and conventional herds.

5. Notation

CBSCC, calculated bulk tank somatic cell count
ECM, energy corrected milk
SCC, somatic cell count

Acknowledgements

Thanks to Jørn Pedersen, Anne Mette Kjeldsen and Pia Flagstad at Danish Cattle and to Jytte Christensen at DIAS for providing data. Special thanks to the farmers who allowed access to the data. This work was funded with grants from the Danish Research Center for Organic Farming (DARCOF) and the Ministry of Food, Agriculture and Fisheries.

References

Anon, I., 1996. Håndbog for kvæghold 1996–1997, Landskontoret for kvæg, Skejby, Denmark, 176 pp.

Barkema, H.W., Schukken, Y.H., Lam, T.J.G.M., Beiboer, M.L., Benedictus, G., Brand, A., 1999. Management practices associated with the incidence rate of clinical mastitis. J. Dairy Sci. 82, 1643–1654.

Bartlett, P.C., Miller, G.Y., Lance, S.E., Heider, L.E., Anderson, C.R., 1992. Environmental and managerial risk factors of intramammary infection with coagulase-negative staphylococci in Ohio dairy herds. Prev. Vet. Med. 14, 129–142.

Enemark, P.S., Kjeldsen, A.M., 1999. Production Results from Organic Herds, LK-meddelelser nr. 353. Landskontoret for kvæg, Skejby, Denmark.

Enevoldsen, C., Elgaard, K.B., Jensen, N.P., Nielsen, K.H., Nørregaard, H.K., Philipsen, J.S., 2000. Identification of interactions and non-linear effects, assessment of herd effects, and model validation in a dairy herd health management context. In: Salman, M.D., Morley, P.S., Ruch-Gallie, R. (Eds.), Proceedings of the Ninth Symposium for the International Society for Veterinary Epidemiology and Economics (ISVEE), August 6–11, 2000, Breckenridge, CO, USA, pp. 1133–1134.

Hamilton, C., Hansson, I., Ekman, T., Emanuelson, U., Forslund, K., 2002. Health of cows, calves and young stock on 26 organic dairy herds in Sweden. Vet. Rec. 150, 503–508.

Hardeng, F., Edge, V.L., 2001. Mastitis, ketosis, and milk fever in 31 organic and 93 conventional Norwegian dairy herds. J. Dairy Sci. 84, 2673–2679.

Hayton, A.J., 1999. Dealing with the organic dairy producer. Cattle Practice 7, 383–387.

Hovi, M., Roderick, S., 2000. Mastitis and mastitis control strategies in organic milk. Cattle Practice 8, 259–264.

Kristensen, T., Kristensen, E.S., 1998. Analysis and simulation modelling of the production in Danish organic and conventional dairy herds. Livest. Prod. Sci. 54, 55–65.

Sjaunja, L.O., Baevre, L., Junkkarinen, L., Pedersen, L., Setälä, J., 1990. A Nordic proposal for an energy corrected milk (ECM) formula. In: Performance recording of animals: State of the art 1990. 27th Session, ICRPMA July 2–6, 1990, Paris. EAAP publication no. 50, Center for Agricultural Publishing and Documentation, Wageningen, Netherlands, pp. 156–157.

Vaarst, M., 1995. Sundhed og sygdomshåndtering i danske økologiske malkekvægbesætninger. Ph.D. thesis, Den kgl. Veterinaer-og Landbohøjskole, Frederiksberg, Denmark.

Vaarst, M., 2000. Landmændenes oplevelse af omlægning til økologisk drift. In: Vidensyntese Om Problemer Ved Omlægning Til økologisk Mælkeproduktion, FØJO-rapport nr. 6/2000. Forskningscenter for Økologisk, Jordbrug, Foulum, Denmark, pp. 47–63.

Vaarst, M., Kristensen, E.S., 1993. Sundhed, sygdomsbekoempelse og reproduktion i økologiske malkekvoetninger 1992–93. Beretning fra Statens Husdyrbrugsforsøg no. 722, 112–119.

Vaarst, M., Enevoldsen, C., 1997. Patterns of clinical mastitis manifestations in Danish organic dairy herds. J. Dairy Res. 64, 23–37.

Vaarst, M., Thamsborg, S.M., Bennedsgaard T.W., Houe, H., Enevoldsen, C., Aarestrup, F.M., de Snoo, A., 2003. Organic dairy farmers' decision making in relation to mastitis treatment. Livest. Prod. Sci. 80, 109–120.

Weller, R.F., Bowling, P.J., 2000. Health status of dairy herds in organic farming. Vet. Rec. 146, 80–81.