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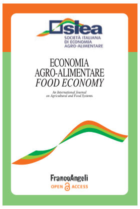

Short-Term Impact of a Zero Concentrate Supplementation on Organic Dairy Production

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Abstract

This study investigates the short-term economic impact of a zero-concentrate supplementation in organic dairy production systems with Holstein cows. Based on experimental data and using prices recorded in 2018 in Switzerland, the study calculates the difference in profits between two annual herbage-based feed rations: one supplemented with 750 kg and the other containing 0 kg concentrates per cow and lactation. The cut in concentrates led to a considerable increase in the average culling rate (14.4 percentage points). If it is assumed that the culling rate cannot be lowered by means of breeding or management adjustments, a zero-concentrate supplementation leads to a 375 CHF drop in profit per cow and year, which is equivalent to a 14% decrease in the remuneration of labor input. If the culling rate could be decreased to the status quo, then not feeding concentrates leads to a smaller, non-significant decrease in profits of 141 CHF per cow and year. Overall, it is concluded that there is a short-term trade-off between profitability and a reduction in concentrates. A zero-concentrate supplementation would be economically feasible only if the culling rate can be kept under control, for instance, by using adapted cow breeds. However, high-quality roughage is a prerequisite and may be more difficult to produce in alpine regions with less favorable production conditions.

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Introduction

Different life cycle assessment studies have stated that the most environmentally friendly animal protein is produced by intensive production systems feeding monogastric animals (mainly pork and poultry) with grains (see Frehner *et al.*, 2020 for more detail). However, these studies miss the fact that large parts of the world's agricultural area is permanent grassland, which depends on ruminants to produce human edible food. Therefore, Van Zanten *et al.* (2018) are not the only ones to argue that "the role of animals in the food system should be centered on converting biomass that we [humans] cannot or do not want to eat into valuable products" (p. 4188).

With a share of 69% permanent grassland and alpine pastures in its total agricultural area (Altwegg, 2015), Switzerland's agriculture is predestined to use ruminants for food production. In accordance with Van Zanten *et al.* (2018), the Swiss government promotes the production of grass-fed meat and milk by means of a dedicated support program that requires that the feed ration consists of at least 90% roughage (Mack *et al.*, 2017). BioSuisse, the largest umbrella organization of Swiss organic farmers, will impose stricter rules and decrease the maximal share of concentrates in the annual ration of dairy cows from 10% to 5% by 2022 (BioSuisse, 2020a; FiBL, 2020). Although this limit is already ambitious, it would still be possible to go a step further and completely cut out concentrates from the ration of dairy cows.

While not feeding concentrates may decrease feed-food competition (Van Zanten *et al.*, 2018), the economic outcome is unclear, since decreasing milk yields combined with increasing cow health issues could turn out to be a serious economic impediment. On the one hand, a cut in concentrates decreases concentrate costs; on the other hand, roughage costs could increase, since cows would need to eat more roughage to offset the cut in concentrates. In the short-term, fertility could decrease because of the negative energy balance resulting from the reduced energy uptake. Reduced fertility not only incurs higher costs for insemination (and fertility treatment), but also leads to a decrease in the revenue from sold calves. Quite apart from the effects on animal health and fertility, the cost-benefit ratio of cutting concentrates may be different for different farms, depending on the cost per kg concentrate, the effect of concentrates on milk yield, and the milk price.

Existing studies have investigated the effect of a reduction in or the absence of concentrates in the feed ration. Delaby *et al.* (2009) and Leiber *et al.* (2017), for instance, worked with reduced (not necessarily zero) amounts of concentrates and focused on animal health, milk yield, and milk composition. Soder and Rotz (2001) calculated the influence of different feed rations on profitability in a U.S. context and found that the profit increases with increasing amounts of concentrates. Ertl *et al.* (2017) compared groups of Austrian organic farms that fed different levels of concentrates in terms of production, animal health, and economics; they found no significant relation between the amount of concentrates fed and the marginal income per cow and year. However, no study has yet analyzed the short-term ceteris paribus effect of not feeding concentrates on the profitability of organic dairy production. This knowledge would help clarify if it were possible to quickly alter the feeding regime while not causing negative economic consequences. In addition, a ceteris paribus setup would allow the most important drivers for changes in profitability to be identified.

Based on a field trial conducted in Switzerland, this study investigates the difference in profitability between a feed ration containing 750 kg concentrates per lactation and a feed ration containing no concentrates (750 kg amounts to 10% of the feed ration per cow and year, given an average herd milk yield above 7000 kg; it is the maximally allowed share, according to the current standards of BioSuisse, until 31 December 2021; BioSuisse, 2021). For that purpose, the study monetizes the performance differences between the two treatment groups by means of standard prices provided by agricultural input suppliers and statistical institutions.

The research questions are:

1. What are the main drivers determining the economic performance of the production system that are influenced by a cut in concentrates?
2. Is a zero concentrate supplementation in the short term economically competitive against the status quo in organic dairy production?

2. Materials and methods

Experimental data

The analysis is based on data from a feeding experiment conducted from 2015 to 2018 on an organic farm in CH-1642 Sorens managing 105 ha agricultural area in the dairy sector (Schori and Münger, 2021). Located in the hill region, the farm represents 503 dairy farms producing under similar climatic conditions, out of the total of 1724 organic dairy farms counted in Switzerland in 2018. The annual base ration consisted of pasture, herbage, and hay. In total, 138 lactations from 92 Holstein cows divided into two different feeding regimes were analyzed. The first regime contained 750 kg concentrates per standard lactation (T750). The second feeding regime did not contain any concentrates (T0). Table 1 shows the number of observations according to the treatment and lactation.

Table 1 - Number of observations and milk yield according to the treatment and lactation

	Number of observations		Total milk yield [kg ECM[1]] per lactation		Weight of cow [kg]	
Lactation	**T750**	**T0**	**T750**	**T0**	**T750**	**T0**
1st	30	30	5868	4923	574	547
2nd	22	21	6123	5555	600	581
3nd	5	6				
4th	6	7				
5th	4	3				
6th	2	2				
3th to 6th (pooled)	18	17	6835	6150	651	657

Source: Authors' calculations based on experimental data.
1. Energy-corrected milk.

Every two weeks during lactation, milk yield was measured and the milk composition (fat, protein, lactose) was analyzed. The number of medical treatments was recorded and grouped in fertility, feeding, claw and leg, mastitis, milk fever, and various issues. In addition, the number of inseminations and the calving intervals were available for each cow and lactation. For the cows receiving concentrates, the amount of protein concentrates and energy concentrates was recorded. Roughage intake was not recorded and had to be estimated based on the intake of concentrates, milk yield, milk composition, body weight, and the pregnancy status of the cow (Agroscope, 2016; assuming 5.7 MJ NEL per kg dry matter of roughage, which is an average value of fresh grazed herbage and hay calculated from the feed analysis results of the experiment).

According to the experimental data, the culling rate of T0 was 14.4 percentage points higher than that of T750. Because the experimental data did not represent a typical herd structure, a different herd structure was assumed to calculate the economic impact of the different treatments (Table 2). Based on a typical Swiss herd structure (Gazzarin *et al.*, 2005) with a culling rate of approximately 31%, the culling rates in T750 and T0 were assumed to be 23.5% and 37.9%, respectively.

Starting from the reference herd structure in Table 2, the herd structure was altered as follows: To increase the culling rate, the value of (100 – [probability of survival]) was increased by the same factor for all lactations.

To decrease the culling rate, the value of (100 – [probability of survival]) was decreased. Therefore, the relationship in terms of (100 – [probability of survival]) stayed the same between lactations. However, the probability of survival and the share of cows in different lactations changed. Decreasing the culling rate increases the share of older cows in the herd.

Table 2 - Assumed herd structure

Probability of survival [%]				**Share [%]**			
Transition	**Reference**	**T750**	**T0**	**Lactation period**	**Reference**	**T750**	**T0**
				1st	24.9	18.0	31.9
1st to 2nd	82.0	89.0	74.4	2nd	20.4	16.0	23.7
2nd to 3rd	86.0	91.5	80.1	3rd	17.6	14.7	19.0
3rd to 4th	72.0	82.9	60.2	4th	12.6	12.2	11.5
4th to 5th	72.0	82.9	60.2	5th	9.1	10.1	6.9
5th to 6th	68.0	80.5	54.6	6th	6.2	8.1	3.8
6th to 7th	65.0	78.6	50.3	7th	4.0	6.4	1.9
7th to 8th	65.0	78.6	50.3	8th	2.6	5.0	1.0
8th to 9th	50.0	69.5	29.0	9th	1.3	3.5	0.3
9th to 10th	50.0	69.5	29.0	10th	0.7	2.4	0.1
10th to 11th	50.0	69.5	29.0	11th	0.3	1.7	0.0
11th to 12th	50.0	69.5	29.0	12th	0.2	1.2	0.0
12th to 13th	50.0	69.5	29.0	13th	0.1	0.8	0.0
13th to 14th	0.0	0.0	0.0	14th	0.0	0.0	0.0

Source: Authors' calculations.
T0 = zero concentrate supplementation treatment.
T750 = treatment with 750 kg concentrate supplementation per cow and lactation.

Assumed Prices

To assess the economic impact of T0 compared to T750, prices had to be assumed for milk, sold calves, sold cows, replacement cows (in first parity), roughage, concentrates, and insemination. Prices were collected for the year 2018, because 2018 represents the most recent year in which the experiment was conducted. It was assumed that the dairy enterprise would not rear on its own, and thus replacing a cow resulted in revenue from selling the culled cow, costs related to buying a cow in her first parity, and revenue from selling a calf.

The cow replacement cost was assumed to be 3660 CHF per cow, whereas sold cows were priced at 3.98 CHF per kg live weight (BioSuisse, 2020b; agristat, 2018). Assuming that crossbreeds were sold for fattening, the price per calve with a 73 kg live weight was estimated to be 377 CHF (BioSuisse, 2020b; agristat, 2018; the optimal live weight for trading calves ranged between 70 and 75 kg in 2018). For roughage, a price of 0.369 CHF per kg dry matter was assumed (Swiss Farmers Union, 2020). The price of energy concentrates and protein concentrates was assumed to be 0.9065 CHF·kg^{-1} and 1.303 CHF·kg^{-1}, respectively (UFA, 2020). Energy-corrected milk (ECM; [kg ECM] = [kg Milk] · (0.38·[% fat] + 0.24·[% protein] + 0.17·[% lactose]) / 3.14; Agroscope, 2016) was priced at 0.8234 CHF·kg^{-1} (Federal Office for Agriculture, 2020). The cost per insemination was assumed to be 59.10 CHF (with the most popular meat breed used to inseminate Holstein cows; Swissgenetics, 2020). Medical treatments did not differ significantly between T0 and T750 in the experiment and were therefore not considered in the economic analysis.

Modelling and calculations

To make most use of the available data, data on each cow in a specific lactation that was recorded during the experiment was "extrapolated" to model all possible lactations during the potential lifetime of that cow. In other words, if data from three lactations of a specific cow were collected, the entire life of that cow was modelled three times. Upon transitioning from one lactation to another, the milk yield of each cow was adapted according to the typical increase in milk yield with increasing lactation, which is shown in Table 1. Because of the limited number of cows in lactations 3 to 6, these lactations had to be collapsed, and, thus, the milk output was assumed constant after the second lactation (e.g., an individual cow in the 750 kg treatment group with a 7000 kg milk yield in the second lactation was assumed to have 7000·5868/6123 = 6708 kg milk yield in the first lactation and a 7000·6835/6123 = 7814 kg milk yield in the third and all following lactations). The weight of the cows was modeled according to the same methodology. The roughage intake was calculated in each lactation (see also section 2.1), while the amount of concentrates, the number of insemination attempts, and the calving interval were held constant for each cow for all lactations. At the start of the lactation, the cow had to be less than 15 years old; otherwise, she was culled. In the last lactation of the cow, revenue was earned from selling the cow. In the first lactation, costs for the replacement of the cow were booked in addition to the revenue from selling the calf.

Using the previously mentioned prices, a cost-benefit analysis was calculated separately for each cow and lactation. Assuming the herd structures given in Table 2, the weighted average revenues per lactation from selling milk, calves, and the cow, as well as the average costs for roughage, concentrates, insemination, and the replacement of the cow, were calculated. Because the calving intervals differed between the cows, revenues and costs were standardized to 365 days in order make the figures comparable between the cows. The difference in the net average profit per cow between the two treatments (T0 vs. T750) was analyzed by means of an analysis of variance (ANOVA).

Because the culling rate turned out to have a major impact on the resulting profitability, the analysis was carried out twice: once assuming that a reduction in concentrates increases the culling rate (herd structure information given in columns "T0" and "T750" in Table 2), as suggested by the experimental data, and once assuming that such an increase could be avoided in the longer term with managerial adjustments and adapted cow breeds (column "Reference" in Table 2).

Subsequently, a sensitivity analysis with regard to the price of milk, calves, replacement cows, culled cows, roughage, concentrates, and insemination was conducted. For each item, the price was changed by 10%, and the profit calculation was conducted once again. The effect of different culling rates on the profit was also analyzed. All calculations were carried out using R and its standard package suite (R Core Team, 2020).

Up until this point, the setup of the analysis only allowed for a comparison of the differences in profits between the two treatments (T0 vs. T750) and not calculating the total profit for each treatment. Therefore, the results of the analysis were amended by full costing data published by Hoop *et al.* (2017). Whenever possible, cost and revenue positions were adapted from 2010-2014 levels for 2018 using official price indices (Federal Office for Agriculture, 2020; agristat, 2019). This approach allowed for comparing the estimated total profit between the two treatments and calculating the remuneration of labor input.

3. Results

Effect of the Treatment

Table 3 shows the difference in profit, milk yield, and calving interval as well as the revenue and cost positions between T0 and T750. To set apart the influence of the different herd structure on profits from the influence of other factors, first, the results assuming the same herd structure in T0 and T750 will be discussed. Due to the significantly reduced milk yield (-786 kg ECM per year) in T0, the revenue from milk is significantly lower (-647 CHF per year). Not surprisingly, T0 benefits from a significant reduction in concentrate cost (-666 CHF per year). However, roughage costs are slightly increased (145 CHF per year, also significant), and, therefore, the net feeding costs are 521 CHF lower in T0. Other revenue and cost positions either do not differ significantly between groups or are too small to mention. Overall, not feeding concentrates leads to a 141 CHF reduction in profits per cow and year when compared to the feed ration containing 750 kg concentrates per cow and lactation. This amounts to a decrease in profit of 0.188 CHF per kg concentrate not being fed or is the equivalent of reducing the milk price by 0.022 CHF per kg milk (-2.6%) assuming business as usual (with the initial milk yield feeding 750 kg concentrates). However, due to the observed variance in the sample, the numeric difference in profit is not significant at the 0.05 level.

Table 3 - Difference between the 750 kg (T750) and 0 kg (T0) treatment, i.e. [value in T0] – [value in T750], as well as probability values according to the ANOVA. The values refer to the attributes, costs, and revenues of a cow during a 365-day period

	Same herd structure	**Different herd structure**
Item	**T0 – T750**	**T0 – T750**
Total profit [CHF]	-141.1 .	-375.3 **
Revenue from milk [CHF]	-646.8 ***	-810.4 ***
Revenue from cows [CHF]	-20.2	271.8 ***
Revenue from calves [CHF]	1.8	50.1 ***
Cost of cow replacement	17.8	485.5 ***
Cost of concentrates [CHF]	-666.2 ***	-666.2 ***
Cost of roughage [CHF]	144.8 ***	87.9 **
Cost of insemination [CHF]	-20.5 .	-20.5 .
Milk yield per year [kg ECM]	-785.6 ***	-984.2 ***
Calving interval [days]	-8.4	-8.4
Weight at end of lactation [kg]	-13.8 .	-31.5 **

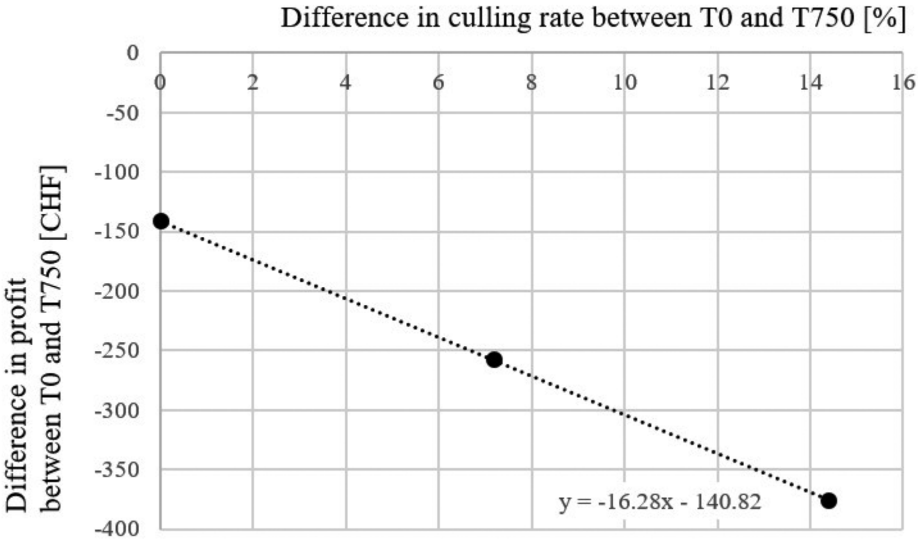
Source: Authors' calculations based on experimental data.
. Significant at the 0.1 level.
* Significant at the 0.05 level.
** Significant at the 0.01 level.
*** Significant at the 0.001 level.
T0 = zero concentrate supplementation treatment.
T750 = treatment with 750 kg concentrate supplementation per cow and lactation.

When a different herd structure (according to the average culling rates resulting from the experimental data) is assumed in T0 and T750, then the differences between T0 and T750 are considerably larger. T0 has an even lower milk yield compared to T750, because, in T750, more cows are in advanced lactations. For this reason, cows in T750 are also significantly heavier at the end of the lactation. The higher culling rate in T0 leads to higher revenues from selling cows and calves but also increases the cost of cow replacement. Overall, not feeding concentrates leads to a 375 CHF reduction in profits per cow and year when compared to a ration containing 750 kg concentrates per cow and lactation. This amounts to a decrease in profit of 0.50 CHF per kg concentrate that is not being fed or is the equivalent of reducing the milk price by 0.057 CHF per kg milk (-6.9%) assuming business as usual (with the initial milk yield feeding 750 kg concentrates). This difference in profit is significant.

Sensitivity Analysis

Figure 1 shows the relationship between the assumed culling rate and the profit difference between T0 and T750. One additional data point was added between "same culling rate" (difference: 0%) and "different culling rates according to the experiment" (14.4 percentage points) to assess whether the relationship is linear. It turned out that the relationship is in fact linear. With each percent difference in culling rate, the profit gap between T750 and T0 increased by approximately 16.3 CHF.

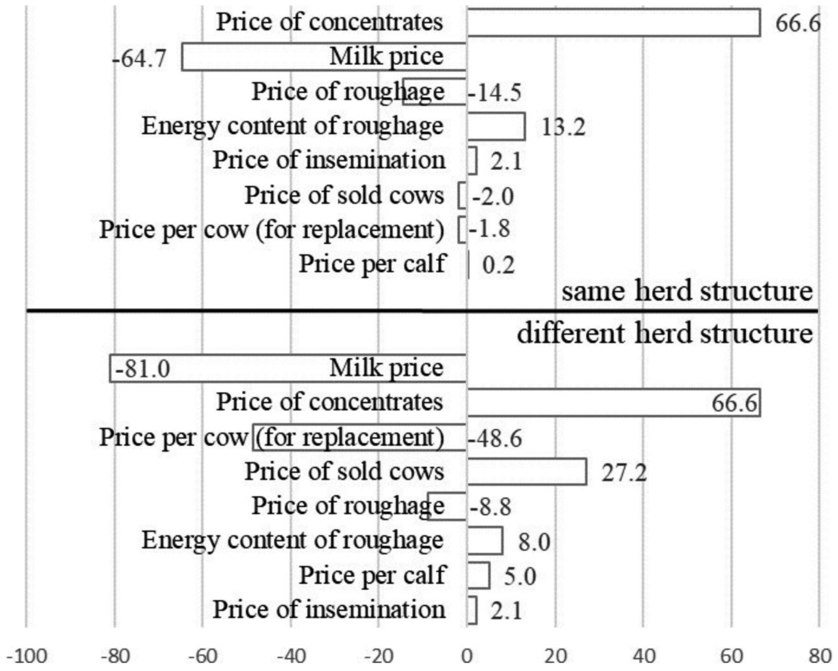
Figure 1 - Sensitivity analysis with respect to the culling rate



T0 = zero concentrate supplementation treatment.
T750 = treatment with 750 kg concentrate supplementation per cow and lactation.

Figure 2 shows the results of the sensitivity analysis with regard to prices. Positive numbers signify that the profitability of T0 compared to T750 improves. Assuming the same herd structures in T0 and T750, if the prices of concentrates were 10% higher, the profit gap between T750 and T0 would decrease by 66.6 CHF from 141.1 CHF to 74.5 CHF per cow and year. Almost equally influential – but with the opposite sign – is the milk price. A 10% increase in milk price would widen the profit gap between T750 and T0 to 205.8 CHF per cow and year. Because the cows in T0 ate more roughage than their counterparts in T750, a higher price for roughage would increase the profit gap between T750 and T0. The energy content of roughage inversely influences outcomes.

Figure 2 - Results of the sensitivity analysis. Influence of a 10% increase in different parameters on the resulting profit difference between the 750 kg (T750) and 0 kg (T0) treatment



Source: Authors' calculations based on experimental data.
T0 = zero concentrate supplementation treatment.
T750 = treatment with 750 kg concentrate supplementation per cow and lactation.

The calculations assuming different herd structures in T0 and T750 are more strongly influenced by the milk price, because, in T750, more cows are in advanced lactations and therefore have higher milk yields. If the milk price were 10% higher, the profit gap between T750 and T0 would amount to 456.3 CHF per cow and year. Because the culling rate is higher in T0, higher cow replacement prices deteriorate the profitability of T0 and therefore widen the profit gap between T750 and T0 by 48.6 CHF per 10% price increase. On the other hand, T0 benefits from more cows being sold, and, therefore, increasing the prices for slaughter cows would increase the profitability of T0 relative to that of T750. However, the effect is 44% smaller than the effect of increased prices for cow replacement.

Income statement

Table 4 contains the income statements of the dairy enterprise according to Hoop *et al.* (2017) as well as adapted income statements for T0 and T750. Assuming equal herd structures in T0 and T750, the changes in revenue and cost positions other than milk, concentrates, and roughage are of minor importance (as already pointed out in Table 3). Assuming different herd structures, T0 generates greater revenue from selling cows and calves (item "Other Revenues") but also has higher animal purchase costs.

Because of the considerable opportunity costs of labor (22.60 CHF per hour) assumed by Hoop *et al.* (2017) and the comparably low profitability of the dairy enterprise, when compared to other enterprises, such as crops, the imputed profit for all variants is clearly negative. When the herd structures do not differ between T0 and T750, remuneration of labor input amounts to 14.15 CHF per hour in T0, which is 4% lower compared to T750. Assuming different herd structures, remuneration of labor input decreases by 12% when no concentrates are fed. For the average Swiss milk producer with 23.8 dairy cows (Hoop *et al.*, 2019), a 4% reduction in the remuneration of labor input sums up to a 3624 CHF decrease in the yearly labor income (a 12% reduction results in a 9638 CHF decrease in yearly labor income).

Table 4 - Income statement of the dairy enterprise according to Hoop et al. (2017) and according to the 750 kg (T750) and 0 kg (T0) treatments. If not stated otherwise, all figures are in Swiss francs per livestock unit of the dairy enterprise (including rearing cattle)

		Same herd structure		**Different herd structure**	
	Hoop *et al.* (2017)	**T750**	**T0**	**T750**	**T0**
Total revenue	**7950**	**8334**	**7669**	**8388**	**7900**
Revenue from milk sold	3338	3723[a]	3076[b]	3777[a]	2966[b]
Other revenues	928	928	910[c]	928	1250[c]
Direct payments	3683	3683	3683	3683	3683
Total costs	**10347**	**10062**	**9538**	**10062**	**9949**
Direct costs	1633	1400	731	1400	1199
Concentrates	908	666[d]	0[b]	666[d]	0[b]
Veterinary expenses andinsemination	252	252	231[b]	252	231[b]
Animal purchase	128	137	154[b]	137	622[b]
Other direct costs	345	345	345	345	345
Imputed land rental cost	359	359	359	359	359
Joint costs	8356	8304	8448	8304	8391
Additional roughage cost	0	0	145[b]	0	88[b]
Labor, machinery, buildings	8356	8304	8304	8304	8304
Imputed profit	**-2397**	**-1728**	**-1869**	**-1674**	**-2049**
Total labor income	2500	3206	3065	3260	2885
Labor input [h/LU]	217	217	217	217	217
Remuneration of labor input[CHF/h]	**11.55**	**14.81**	**14.15**	**15.06**	**13.32**

Source: Hoop *et al.* (2017; Table 27) and authors' calculations based on experimental data. Nominal values of T0 and T750 were adapted using price indices (see section 3).

h = hours, LU = livestock units, CHF = Swiss francs.

a) Revenue adapted according to the milk yield in Hoop *et al.* (2017) and T750.
b) Revenue/cost adapted according to the difference between T0 and T750.
c) Revenue adapted according to the difference in sales of calves and culled cows between T0 and T750.
d) Cost was set to the actual cost of concentrates in T750.

4. Discussion

Compared to the organic dairying in Hoop *et al.* (2017), the results from the experiment show higher profitability, because the farms analyzed by Hoop *et al.* (2017) were located in mountainous regions. These farms produce under less favorable production conditions, which manifests in lower revenue from milk. Furthermore, the results of Hoop *et al.* (2017) refer to the whole dairy enterprise (including rearing), and, therefore, the system boundaries might not always be 100% consistent.

Some limitations regarding the representability of our findings should be pointed out.

In terms of size, the dairy farm on which the experiment was conducted – 109 ha managed primarily for research and educational purposes – is not representative of an average organic dairy producer in the same production region (24.1 ha agricultural area in 2018). This should not be of concern, however, because the assumed prices (costs) were derived from official data sources, so the analysis should not have been influenced by scale effects. The effect of assumed prices and costs on the results was in turn assessed by a sensitivity analysis. The findings from the sensitivity analysis allow the calculations to be adapted to the situation of other farms facing different conditions; hence, the results should be generalizable. Lastly, in terms of generalizability, the cow breed needs to be addressed.

In the experiment serving as the base for the economic evaluation, Holstein cows of Swiss (2/3 of the lactations) and New Zealand (1/3 of the lactations) origin were investigated. Because of the small number of lactations, the analysis could not be conducted separately for the different Holstein origins. It must be admitted that Holstein of Swiss origin may not be a cow type typically used in low-input systems. Different breeds may have different capacities to produce milk without concentrates. Management may also play an important role. This is supported by the results of Ertl *et al.* (2014), who did not find significant differences in marginal income (per cow and year) between groups of farms with different shares of concentrates in the feed ration. Indeed, farms not feeding concentrates managed herds with higher average cow age compared to farms feeding more than 1400 kg concentrates per cow and year. Ertl *et al.* (2014) also showed that farms not feeding concentrates tended to have lower veterinary costs per cow and year. Both findings are in contrast to our experimental findings and suggest that the negative impact of a zero concentrate supplementation is only relevant in the short-term but can be overcome by means of breeding and/or changes in management.

On the contrary, Soder and Rotz (2001) calculated that cutting concentrates considerably decreases profits. However, in Swiss agricultural markets, the price of concentrates is high relative to the price of milk. This is even more pronounced in Swiss organic markets and makes a low-input strategy economically more attractive. In Germany, for example, the price of concentrates relative to the price of milk was 83% in 2019. In Swiss conventional markets, it was 94%, and, in Swiss organic markets, it was 111% (FAO 2020; Cerca *et al.* 2019:36; Federal Office for Agriculture, 2020; UFA, 2020).

Reducing roughage costs (increased grazing time, decreased share of conserved roughage) would make low-input strategies even more attractive, but as Ivemeyer *et al.* (2014) pointed out, high roughage quality is essential to succeed in reducing concentrates. As roughage quality depends on production conditions, cutting concentrates in the ration is easier to implement in regions with highly productive grasslands. In mountainous regions, where the energy content of roughage tends to be lower, this could be challenging.

5. Conclusions

The culling rate, milk price, and price of concentrates are crucial for the economic success of a zero-concentrate supplementation. The lower the milk price and the higher the price for concentrates, the more attractive cutting concentrates in the feed ration becomes. If a cut in concentrates considerably increases the culling rate, a zero-concentrate supplementation is not competitive against a 750 kg supplementation. When the culling rate is kept constant, not feeding concentrates may be economically equivalent to feeding 750 kg per cow and standard lactation.

In the setting analyzed, there is a short-term trade-off between profitability and a zero concentrate supplementation; however, the literature suggests that this trade-off can be overcome given that the farm is able to produce high-quality roughage, and management and cow breeds are geared toward a low-input production paradigm.

We conclude that a zero-concentrate supplementation according to the "feed no food" principle should be feasible in organic dairying, but only if the production system is gradually changed. Because the total amount of organic milk produced in Switzerland could decrease due to a mandatory cut in concentrates, there is even a chance of lower milk yields being (partially) offset by a higher equilibrium milk price. Further research would be necessary in order to determine the robustness of our findings with regard to other cow breeds.

References

Agristat (2018). *Statistisches Monatsheft Februar 2018 bis Januar 2019.* Brugg: Schweizer Bauernverband.

Agristat (2019). *Statistische Erhebungen und Schätzungen über Landwirtschaft und Ernährung 2018*. Brugg: Schweizer Bauernverband.

Agroscope (2016). *Fütterungsempfehlungen für Wiederkäuer – Grünes Buch*. -- www.agroscope.ch/gruenes-buch.

Altwegg, D. and Sektion Geoinformation (2015). *Die Bodennutzung in der Schweiz. Auswertungen und Analysen*. Neuchatel: Swiss Federal Statistic Office.

BioSuisse (2020a). Who is BioSuisse. Retrieved March 2, 2020, -- from www.bio-suisse.ch/en/whoisbiosuisse.php.

BioSuisse (2020b). Bio-Richtpreise Archiv. -- Retrieved 21 February, 2020, from www.bioaktuell.ch/markt/biomarkt/markt-Biofleisch-allgemein/schlachtvieh/richtpreise.html.

BioSuisse (2021). Richtlinien für die Erzeugung, Verarbeitung und den Handel von Knospe-Produkten. -- Retrieved April 8, 2021, from www.bio-suisse.ch/media/Produzenten/Richtlinien/bio_suisse-richtlinien_2021_de_def.pdf.

Federal Office for Agriculture (2020). -- Retrieved 25 February, 2020, from www.blw.admin.ch/blw/de/home/markt/marktbeobachtung/milch.html.

Cerca, M., Mann, S., Kohler, A., Wunderlich, A., Logatcheva, K., van Galen, M., Helmling, J., van Berkum, S., Rau, M.L., & Baltussen, W. (2019). *Concentrate animal feed as an input good in Swiss agricultural production – The effects of border protection and other support measures*. Bern: SECO.

Delaby, L., Faverdin, P., Michel, G., Disenhaus, C., & Peyraud, J.L. (2009). Effect of different feeding strategies on lactation performance of Holstein and Normande dairy cows. *Animal*, *3*(6): 891-905. doi: 10.1017/S1751731109004212.

Ertl, P., Knaus, W., & Steinwidder, A. (2014). Comparison of zero concentrate supplementation with different quantities of concentrates in terms of production, animal health, and profitability of organic dairy farms in Austria. *Organic Agriculture*, *4*(3): 233-242. doi: 10.1007/s13165-014-0077-z.

FiBL (2020). Fütterungsrichtlinien 2020 nach BioSuisse. Merkblatt Nr. 1398. *Research Institute of Organic Agriculture, Frick*.

FAO (2020). FAOSTAT Producer Prices – Annual. -- Retrieved March 5, 2020, from www.fao.org/faostat/en/#data/PP.

Frehner, A., Muller, A., Schader, C., Boer, I.J.M.D., & Zanten, H.H.E.V. (2020). Methodological choices drive differences in environmentally-friendly dietary solutions. *Global Food Security*, *24*, 100333. doi: 10.1016/j.gfs.2019.100333.

Gazzarin, C., Amman, H., Schick, M., Van Caenegem, L., & Lips, M. (2005). *Milchproduktionssysteme in der Tal- und Hügelregion. Was ist optimal für die Zukunft?* Tänikon: Agroscope.

Hoop, D., Spörri, M., Zorn, A., Gazzarin, C. & Lips, M. (2017). Wirtschaftlichkeitsrechnungen auf Betriebszweigebene. In: M. Lips (Ed.), *Wirtschaftliche Heterogenität auf Stufe Betrieb und Betriebszweig*. Tänikon: Agroscope.

Hoop, D., Schiltknecht, P., Dux-Bruggmann, D., Jan, P., Renner, S., & Schmid, D. (2019). Grundlagenbericht 2018. Tänikon: Agroscope.

Ivemeyer, S., Walkenhorst, M., Holinger, M., Maeschli, A., Klocke, P., Neff, A.S., Staehli, P., Krieger, M., & Notz, C. (2014). Changes in herd health, fertility and production under roughage based feeding conditions with reduced concentrate input in Swiss organic dairy herds. *Livestock Science*, *168*: 159-167. doi: 10.1016/j.livsci.2014.08.009.

Mack, G., Heitkämper, K., Käufeler, B., & Möbius, S. (2017). *Evaluation der Beiträge für Graslandbasierte Milch- und Fleischproduktion (GMF)*. Tänikon: Agroscope.

Leiber, F., Schenk, I.K., Maeschli, A., Ivemeyer, S., Zeitz, J.O., Moakes, S., Klocke, P., Staehli, P., Notz, C., & Walkenhorst, M. (2017). Implications of feed concentrate reduction in organic grassland-based dairy systems: a long-term on-farm study. *Animal*, *11*(11):, 2051-2060. doi: 10.1017/S1751731117000830.

R Core Team (2020). R: A Language and Environment for Statistical Computing. R Foundation for Statistical Computing, Vienna.

Röös, E., Bajželj, B., Smith, P., Patel, M., Little, D., & Garnett, T. (2017). Greedy or needy? Land use and climate impacts of food in 2050 under different livestock futures. *Global Environmental Change*, *47*: 1-12. doi: 10.1016/j.gloenvcha.2017.09.001.

Schader, C., Muller, A., Scialabba, N.E.-H., Hecht, J., Isensee, A., Erb, K.-H., Smith, P., Makkar, H.P., Klocke, P., Leiber, F., & others (2015). Impacts of feeding less food-competing feedstuffs to livestock on global food system sustainability. *Journal of the Royal Society Interface*, *12*(113), 20150891. doi: 10.1098/rsif.2015.0891.

Swiss Farmers Union. (2020). Richtpreise für Futtermittel. Retrieved 25 February, 2020, -- from www.sbv-usp.ch/de/preise/pflanzenbau/futtermittel/.

Schori, F., & Münger, A. (2021) Effects of an all-herbage versus a concentrate-supplemented ration on productivity, body condition, medical treatments and reproduction in two Holstein cow types under organic conditions. *Livestock Science*, 257. doi: 10.1016/j.livsci.2021.104768.

Soder, K.J., & Rotz, C.A. (2001). Economic and Environmental Impact of Four Levels of Concentrate Supplementation in Grazing Dairy Herds. *Journal of Dairy Science*, *84*(11): 2560-2572. doi: 10.3168/jds.S0022-0302(01)74709-1.

Swissgenetics (2020). *Requested price information provided by phone*.

Van Zanten, H.H.E., Herrero, M., Van Hal, O., Röös, E., Muller, A., Garnett, T., Gerber, P.J., Schader, C., & De Boer, I.J.M. (2018). Defining a land boundary for sustainable livestock consumption. *Global Change Biology*, *24*(9): 4185-4194. doi: 10.1111/gcb.14321.

UFA (2020). *Requested price information provided by e-mail*.

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