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FEED USE EFFICIENCY ON SMALL SCALE DAIRY FARMS IN THE SOUTH OF RIO GRANDE DO SUL, BRAZIL

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ABSTRACT

Types and amounts of feeds used, milk offtake and body weight changes of cows were monitored during 12 months on farms of cash crop and milk producers (CM) and cash crop producers with surplus milk marketing (Cm). The intake of feed dry matter (DM) and crude protein were different between the two production systems across the seasons. On a yearly basis, cows ingested 97.3g DM/kg$^{0.75}$ and 100.8g DM/kg$^{0.75}$ per day, consisting to 48% and 64% of forage from pastures, 33% and 17% silage or cut green forage and 18% mix of concentrates and grains on CM and Cm farms, respectively. The yearly body weight change on CM was 4.5kg as compared to 7.0kg on Cm. Daily milk production per cow was 9.8L on CM and 10L on Cm and varied between seasons for both production systems. In both systems, feed intake was below the recommendations for lactating cows, leading to a very low feed use efficiency of 0.78L/kg feed DM on CM and 0.81L/kg feed DM on Cm. It is concluded that more cautious feeding of cows in both systems might increase use efficiency of fodder resources for milk production, and feed intake on both farms should be improved.

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INTRODUCTION

Agricultural and livestock productivity growth contribute to better nutrition through raising incomes, especially in countries where the sector accounts for a large share of the economy and employment, and through reducing the cost of food for all consumers (FAO, 2013). Over the last five decades the global dairy sector has seen substantial changes with major enlargement of farms, intensification and efficiency increase of production, and increasing complexity of value chains, driven by the demand from a growing human population and increasing (urban) incomes (FAO, 2012) in the livestock sector. This growth was achieved by new developments in plant and animal breeding, nutrition, forage production, animal health care, housing, automation processes and supporting policies, strategies and organizations (FAO, 2012). Such changes are however not to be seen across the whole dairy sector, and while some developing countries have experienced a major expansion of small-scale milk production, small-scale dairying in other countries has largely stagnated, instead of supplying important added value to producers and the local or regional dairy sector (FAO, 2012; Faye and Konuspayeva, 2012). High prices and very good climatic conditions during 2011 boosted dairy production in Argentina by more than 10%, breaking domestic output records. Improved returns on investment, increased management efficiency and the economies of scale will drive future production gains in the dairy sector. Milk production is expected to grow by more than 3.4% annually in the next ten years (OECD/FAO, 2012). In Mexico, on the other hand, farmers had to cope with reduced forage supplies due to dry weather which led to stagnating milk output in 2011.The dairy sector in Mexico is expected to be modernized with investments in infrastructure and animal genetics, supported by government, and it is projected that milk production will increase annually by 0.5% on average (OECD/FAO, 2012). Brazil ranked fourth among the international milk producers in 2012, with a production of 33,054 million liters of milk (FAO, 2013). The country's milk production is projected to grow by 1.7% annually, stimulated by incentives of private companies, favourable prices and growing domestic demand, but also by development programs aiming at increasing productivity through animal breeding and pasture improvements (OECD/FAO, 2012). The dairy sector also plays an important role for Brazil's regional development, offering around three million jobs, and milk is among the three most important agricultural products of the country. The southern and southeastern regions produce 65% to 70% of milk in Brazil, and the state of Rio

Grande do Sul is ranking second in national milk production, contributing 14% of the total amount of produced milk (IBGE, 2010), and 3.5% and 8% to the national and the national agricultural GDP, respectively (Montoya and Finamore, 2010). Across the country, small-scale farmers supply 70% of the produced milk (MDA, 2009). On these farms, land area is less than 100 hectares in size, family labor prevails over hired labor and work is supervised by the producer. At present, of 441,000 small scale farmers in Rio Grande do Sul state 134,000 are milk producers, supplying up to 100 liters each per day (IBGE, 2012). Per cow the annual milk production in Brazil and Rio Grande do Sul state, respectively, averages 1,260 liters and 2,236 liters (IBGE, 2012), the latter value pointing to the favorable environmental conditions for dairy operations in this state. The botanical diversity, especially of grasses, enables a daily biomass production of 25 - 35 kg DM/ha even on native pastures during spring and summer, and of 0 - 5 kg DM/ha in winter, resulting in an annual forage production of 2500 - 4000 kg DM/ha (Carvalho et al., 2006). The south of Rio Grande do Sul, region studied here, is a major area of small scale agriculture in Brazil (MDA, 2009). In this region, milk is mostly produced in low quantities by less specialized farmers (Chapter 2), for whom milk production is a labor-intensive activity with low contribution to overall family income. In order to explain differences in per cow and per farm performance of small-scale milk producers, their management strategies and milk marketing channels were analyzed (Chapter 3). The results indicated that area of pasture and fodder production was an influential variable in all cases, independent of the marketing channel used. Therefore the present chapter explores the quantitative and qualitative supply of feed to dairy cattle herds of the major types of dairy farmers in the study region (Chapter 2).

MATERIALS AND METHODS

Study location: The state of Rio Grande do Sul is located in the south of Brazil, comprising an area of 281,748 km^2. In 2009, the state's population amounted to 10.7 million with an average population density of 38 people/km^2. The Human Development Index of the state averages 0.83; the region's Gross Domestic Product (GDP) was 100.1 million US$ in 2009 when the annual per capita income was 8350 US$. Agriculture plays an important economic role and in 2009 accounted for 10.2% of the state's GDP (Defesa Civil do Rio Grande do Sul, 2011). The main cities the south of Rio Grande do Sul, are Canguçu (31°23' S, 52°40' W), Pelotas (31°46' S, 52°21' W), and São Lourenço do Sul (31°22' S, 51°59' W). In this low-lying region (7 - 500 m a.s.l.) a humid subtropical climate is predominant, with four distinct seasons and warm summers (December - February). A regular dry season is not observed and annual precipitation ranges from 1250 - 1600 mm, with rainfall concentrated in the winter months (June – August, 350 – 500 mm per month (Defesa Civil do Rio Grande do Sul, 2011). The region hosts a variety of bedrocks and soils with vegetation communities dominated by herbaceous plants and shrubs. "Pampa" plains are observed in most of the region, interspersed by mounds ("Coxilhas") covered by grasses of the genera *Stipa, Agrostis, Paspalum* and *Axonopus*. The ligneous vegetation is dominated by thorny and deciduous species of the genera *Acacia*, *Prosopis* and *Acanthosyris* and the introduced (Australasian) species *Araucaria angustifolia* present in gallery forests (IBGE, 2011). The main livestock activity in the region is dairy cattle husbandry on small scale farms (family farms), followed by dairy cattle production on large scale farms. Small and large scale beef cattle production is also present in Rio Grande do Sul, but is rarely observed in the study region. As a general observation, small-scale farming systems operate alongside modernized and mechanized large-scale farms that cultivate rice, soya beans and wheat (Sacco dos Anjos, 1995). Small-scale farms show a higher diversity of agricultural production, practicing subsistence and cash cropping, with tobacco, rice, soya beans, black beans and vegetables/fruits being the main products (Alonso and Bandeira, 1994).

Selection of study farms: A baseline survey covering 200 family farms was conducted from February to April 2010 in the rural areas surrounding the three cities (Chapter 2). Based on the collected data, three farm types were differentiated based on categorical principal component analysis followed by two step clustering. These groups were milk producers (group M, n=7); cash crop and milk producers (group CM, n=74) and cash crop producers with surplus milk marketing (group Cm, n=118). Of groups CM and Cm only, representative farmers were selected (CM: n=6 that is 7% of that group; Cm: n=12 that is 11%) for qualitative and quantitative on-farm monitoring of the management of dairy animals. In this way a total of 219 cows in lactation were covered by the monitoring. The dominant breeds were crosses between local breeds and imported milk breeds, followed by Jersey and Holstein cattle. Feed resources for cattle herds included grazed natural or sown pasture as well as stall-fed green fodder crops, maize silage and grain-based mixed concentrate feeds. On all farms lactating animals were fed twice daily (in the morning and evening, with concentrates only once if they grazed during daytime) at milking; the latter was done by hand. Animals stayed in the backyard or grazed on pastures during the day, and in some cases were locked in a cattle shed during the night.

Data collection and analysis: Monitoring of feed offer to cattle, and of milk offtake, weight changes and changes in animal numbers in the 18 cattle herds covered a period of 12 months (August 2010 to July 2011). All measurements were carried out in intervals of 4 weeks; milk production was additionally measured by farmers once per week; all milk measurements took place on an individual cow basis, once in the evening and in the following morning. A semi-structured questionnaire was used to collect information on all demographic events (animal exits for any reason, and entries through purchases, births) that had occurred in the herds since the previous visit. In addition the use of veterinary products and the sale of milk were recorded along with details on daily husbandry practices. Body weight (BW) of adult animals was estimated from body measurements taken with a plastic thoracic tape that allowed for a direct estimate of body weight according to cattle breed (Mota et al., 2012). To determine the types and amounts of feeds offered at the homestead, a portable electronic weighing scale of 100 kg capacity and 0.02 kg accuracy was used to measure feed offered every week; samples (250 g dry matter) of all feeds offered were taken monthly and air-dried before storage; samples of a given type of feed were pooled per household and season for proximate analysis. Feed intake from pasture was estimated based on grazing time, whereby it was assumed that one hour of grazing allowed for 1.2, 1.3, 1.4 and 1.5 kg of dry matter intake from natural pasture, millet, oat/ryegrass mixture and ryegrass, respectively (Casali, 2012). To determine the types and amounts of feeds offered at the homestead, a portable electronic weighing scale of 60 kg capacity and 0.05 kg accuracy was used; samples (500 g dry matter, DM) of all feeds offered were taken monthly and air-dried before storage; samples of a given type of feed were pooled per household and season for proximate analysis.

Samples of feed offered (pasture vegetation, green fodder, silage and concentrates) were milled (1 mm sieve) and analyzed for dry matter (DM) concentration by drying 5 g of air-dry sample material at 105ºC for 5 h. Organic matter (OM) was derived by the difference between dry sample and the residue (crude ash, CA) after ignition at 550°C (Naumann et al., 2004). A Vario MAX CNS analyzer (Elementar Analysensysteme GmbH, Hanau, Germany) was used to determine the nitrogen (N) concentration with phenylalanine serving as standard; crude protein concentration was derived from these values (N x 6.25). The NDF concentration of ash free matter was analyzed according to Van Soest et al. (1991) with a semi-automatic ANKOM220 Fiber Analyzer (ANKOM Technology, Macedon, NY, USA) without using decaline or sodium sulphite. *In vitro* concentration of cellulose-digestible organic matter (CDOM) was determined via pepsin cellulose solubility of OM (De Boever et al., 1986) according to [Eq. 1]:

$$CDOM = \frac{100 - (940 - CA - 0.62\ EULOS - 0.000221\ EULOS^2)}{(1000 - CA)}$$

Where by CA = crude ash (%) and EULOS = non-soluble enzymatic substance.

Statistical analysis of data was computed with SPSS version 19.0 (IBM 2010), whereby descriptive statistics were performed for all variables. Differences between the two production systems and between the four seasons (winter, spring, summer and fall) were explored using the non-parametric Kruskal-Wallis test for independent samples. Significance was declared at $p<0.05$.

RESULTS

Feeding of dairy cattle herds: All dairy operations covered in the present study were forage based systems in which forage from natural and cultivated pastures contributed to animal nutrition. Cultivated pastures were sown with black oat (*Avena strigosa* S.) and ryegrass (*Lolium multiflorum* L.) and especially grazed in winter. Cultivated summer forage was less important and mainly consisted of pearl millet (*Pennisetum americanum* L.). Cattle were grazing daily, spending on average 8 h/d (CM: ±2.4, Cm: ±2.8) on the pastures. Maize silage was offered to animals as a feed complement, together with concentrates and grains mixed by the farmers (Table 1, Table 2). Across the year, daily DM intake of lactating cows as calculated from daily time on pasture (see section 4.3) and measured offer of stall-fed feedstuffs averaged 97.3 g DM/kg$^{0.75}$ (±24.34) and 100.8 g DM/kg$^{0.75}$ (±20.23) on CM and Cm farms, respectively (Figure 1). This provided an average daily intake of 14.9 g CP/kg$^{0.75}$ (±6.68) and 11.6 g CP/kg$^{0.75}$ (±5.23) to CM and Cm cows, respectively. The concomitant intake of NDF was 49.2 g/kg$^{0.75}$ (±12.98; CM) and 53.6 g/kg$^{0.75}$ (±9.41; Cm), and for CDOM a daily intake of 75.0 g/kg$^{0.75}$ (±26.37; CM) and 74.6 g/kg$^{0.75}$ (±19.44; Cm) was calculated (Figure 2).

Body weight development and milk yield: The body weight of adult cows in the studied herds averaged 433 kg (±33.6) across farms and seasons, and the average annual weight gain was 6.9 kg (±12.21) per

Table 1. Contribution of different feedstuffs to daily feed dry matter intake of a dairy cow (kg DM/d) on CM and Cm farms across the four seasons of a year

Feed type	Farm type	n	Winter		Spring		Summer		Fall	
			Mean	SD	Mean	SD	Mean	SD	Mean	SD
Ryegrass	CM	5	4.9	±0.76	1.8	±0.34			1.8	±0.34
	Cm		6.2	±2.61						
Ryegrass & oat	CM	3	6.7	±0.37			6.7	±0.37		
	Cm		7.0	±2.42					7.3	
Millet	CM	2			5.4		5.7		5.9	
	Cm	2			7.5					
Natural pasture	CM	6	5.3	±1.01	5.6	±0.81	5.9	±0.84	5.9	±0.82
	Cm		5.3	±1.01	5.6	±0.81	5.9	±0.84	5.9	±0.82
Pasture mix	CM	2	2.3		1.3					
	Cm									
Silage	CM	2	6.4		4.2				6.5	
	Cm		3.0	±1.77	4.4	±1.15	3.2	±0.68	4.6	±1.64
Grain mix	CM	8	10.4	±0.36	10.7	±0.50	10.7	±0.50	10.5	±0.68
	Cm		3.0	±1.51	3.8	±1.27	3.4	±1.63	5.4	±0.96
Concentrate 20%	CM	8	1.35	±0.38	2.7	±0.97	2.1	±1.62	1.6	±0.98
	Cm		3.3	±1.26	2.06	±0.62	2.4	±0.96	2	±1.11

Grain mix: homemade concentrate; Concentrate: purchased concentrate (composition: maize, sorghum, wheat, soybean and rice bran, salt and urea).

Table 2. Quality of different types of feedstuffs used on CM and Cm farms, average across a year (values in % of DM)

Feedstuff	Farm type CM					Farm type Cm				
	n	DM	CP	NDF	CDOM	n	DM	CP	NDF	CDOM
Ryegrass	6	15	17.1	52.2	79.9	7	15	19.6	53.4	71.4
Natural pasture	3	19	11.3	64.9	76.6	12	22	8.9	62.1	74.8
Pasture mix	4	16	9.5	51.0	65.0	9	23	11.1	39.2	72.8
Silage	2	21	7.3	51.9	70.8	11	13	6.7	55.6	67.1
Grain mix	9	90	19.5	37.5	70.3	26	90	12.7	36.3	70.7
Concentrate	5	89	17.8	17.9	78.5	7	88	21.4	25.4	76.2

Millet was included in pasture mix; Ryegrass and oat were included in ryegrass.
DM: dry matter (in % of fresh matter); CP crude protein; NDF neutral detergent fiber, CDOM cellulose-digestible organic matter.

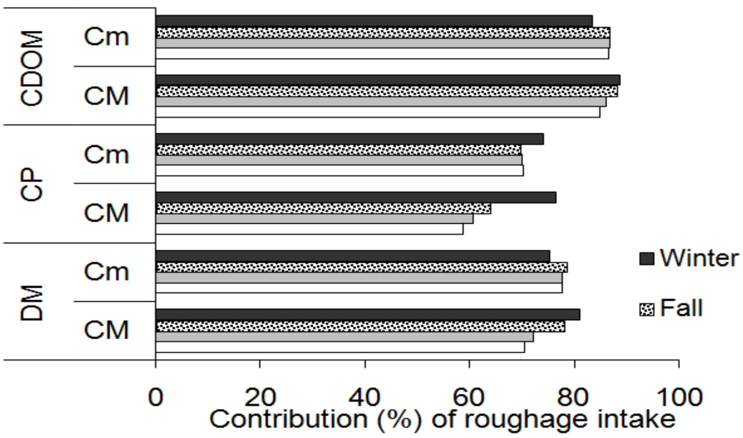

Figure 1. Average seasonal contribution of pasture intake of dry matter (DM), crude protein (CP), and cellulose-digestible organic matter (CDOM) by dairy cattle on CM and Cm farms across the four seasons of a year

animal. Significant differences ($p<0.05$) where observed between farm types and seasons (Table 3). Daily milk offtake per lactating cow averaged 9.8 l (±4.35) and 10.0 l (±4.82) on CM and Cm farms, respectively ($p<0.05$). Within different seasons, however, significant differences ($p<0.05$) in daily milk offtake per cow were observed between the two farm types; seasonal differences were also

DISCUSSION

Pasture based dairy systems are defined as those in which more than 50% of the animals' diet is provided by grazing. These systems require less investment in installations and technologies, but need more land area (Fontaneli et al., 2006). One of the main constrains of pasture-based grazing systems is the limited dry matter intake of highly productive dairy cows, resulting in the inability to meet their energy and nutrient requirements for milk production (Chilibroste et al., 1999). On the other hand, an advantage of milk production in the studied region is the favorable environment that allows a year-round pasture-based feeding system with green roughages. The botanical diversity, especially of grasses, and their predominance during summer leads to a high native forage production of 2500 - 4000 kg DM/ha (Carvalho, 2006). Animal feeding is based on forage in most dairy farms in southern Rio Grande do Sul (Martins et al., 2006), which was also the case in the present study. All farmers cultivated winter and summer pasture areas of 0.6 and 0.1 hectares per animal (Chapters 2, 3). Ryegrass was one of the most important forages for dairy cattle, especially during winter, because it has a high forage yield and good nutritive value, and hence provides a cheaper feed than silage or concentrates (Smit et al., 2005). Since the forage is grazed, labor requirements connected to feeding the animals are also minimal. Among the summer forages, pearl millet had a crude protein content of 13% which is in accordance with the 10 - 21% CP given by Singh et al. (1987). Similarly, the CP content of the winter forage *Lolium multiflorum* of 19% was in the range of the values (9 - 28%) given by Vose and Breese (1964). Mixed with black oat, a ration with 19 - 21% CP can be obtained (Pereira et al., 2005).

As far as the amounts of concentrate and grains are concerned that were offered, these were not always equivalent to 0.75% of the animals body weight as suggested by Pereira et al. (2005). Yet, protein supplementation did not influence body development of grazing Jersey heifers near Pelotas, once the animals' nutritional requirements were met by cultivated winter forage (70% *Lolium multiflorum* plus 30% *Avena strigosa* (Pereira et al., 2005). In the same region, milk production in two different systems did not contrast although the first system relied on a diet of concentrates, maize or sorghum silage and cultivated ryegrass pasture, and the second one did not offer concentrate or silage in addition to the ryegrass pasture (Martins et al., 2006) – this points to the high quality and good availability of this forage. However, the DM intake calculated from measured offer of stall-fed feeds and estimation of feed intake on pasture was much lower than the values recommended for dairy cattle, which vary between 3.5% and 5% of body weight (Van Soest et al., 1991; Nörnberg et al., 2006). One problem of the present approach lies in the estimation of feed intake during grazing, which, although based on data gathered in the region, seems to considerably underestimate the animals' feed intake. In consequence, the calculated values of feed use efficiency are for both farm types reflecting inefficiency when compared to feed the recommended feed efficiencies of 1.3 to 1.6 according lactation period (Hutjens, 1995). Although the farmers in group CM were adjusting animals' diets with the intention to improve it, in reality they were just replacing one feed by another; when their animals grazed cultivated pasture that was of higher quality than the natural pasture they reduce the amount of concentrate and grains offered, when they fed silage they shortened daily grazing time and reduced the offer of concentrate and grains. Farmers in this group reap an important income contribution from dairy farming (Chapter 3), which could be enhanced through better management of feed resources. Cm farmers mainly produce milk for home consumption, marketing only surplus production. The amount and quality of feed offered to animals in this group was not in accordance with feeding recommendations for dairy animals. This can be explained by their low investments in the dairy unit, small herd sizes, reduced pasture areas and limited labor endowment that has to be allocated to various farming activities (Chapter 2). Although earnings from milk production contribute little to overall farm income in this system, the number of small-scale family farms that were classified as Cm producers (Chapter 2) indicates that a consequential improvement of feed use efficiency on these farms would be of great benefit: Firstly for the regional milk production to which, by the mere numbers, Cm farmers contribute substantially; secondly by improving the milk-derived share of income of Cm farmers; and thirdly by securing the livelihoods of people employed in the regional milk value chain dominated by farmer cooperatives, of which the most important members, in numbers, are also the Cm farmers.

CONCLUSIONS

A more efficient feed utilization on the small-scale family farms in the south of Rio Grande do Sul should aim at improvement in amount and quality of feed intake, adequate management of cultivate pastures on CM farms, and diversification of feed offered on Cm farms. Extension services provided by cooperatives, private companies and the governmental sector should provide farmers with the respective knowledge wherever necessary. Seasonal problems of low feed quality and limited feed offer could be overcome by an adequate management of cultivated pastures, and by using silage and higher amounts of concentrate and grains as feed. Without substantial assistance in feeding management and a sustainable improvement of feed use efficiency – and thereby reduction of costs of milk production – CM farmers will turn into Cm farmers and the latter will drop out of milk production in the near future. This would also endanger the livelihoods of the substantial number of employees in the regional cooperative dairy value chains.

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