EAAP 2011, Session 44 - Milk and meat product quality (Food Quality symposium), Abstract 10116 , D.SilvaVillacorta@massey.ac.nz

Characteristics of herds that produce milkfat with a higher than average concentration of unsaturated fatty acids

D. Silva Villacorta[1]*, N. Lopez-Villalobos[1], H. T. Blair[1], R. E. Hickson[1], A. K. MacGibbon [2] R.G. Snell[3]

[1] Institute of Veterinary, Animal and Biomedical Scieces, Massey University, Private Bag 11-222, Palmerston North 4442, New Zealand

[2] Fonterra Co-operative Group, Dairy Farm Rd, Palmerston North, New Zealand

[3] School of Biological Sciences, Center For Brain Research, University of Auckland, Auckland, New Zealand.

* Corresponding author: D.SilvaVillacorta@massey.ac.nz

ABSTRACT

In recent years, there has been a growing interest in the manipulation of milkfat composition at the farm level, prompted by the trend in consumer demands toward healthy dairy products with varied functionality. The nutritive value and manufacturing characteristics of milk can be improved by increasing the concentration of unsaturated fatty acids (UFA) in milkfat. The current research compared, via simulation, the characteristics of farms that produce milkfat with high or low concentration of UFA under a seasonal pastoral system. A stochastic model based on a variance-covariance matrix of milk traits and liveweight was used to generate 2 groups of farms. The L UFA group (30 farms) produced milkfat with a UFA concentration around the population average and the H UFA group (30 farms) produced milkfat with at least 4 percent points above the population average. All simulated farms had 130 hectares and a herd size of 351 cows with a spring calving pattern. For each farm, it was assumed that 10 tonnes of pasture dry matter were grown per hectare per year, with supplements being used to cover feed deficits. The simulation was replicated 100 times to find a 95% confidence intervals for the high and low UFA groups using a bootstrap method. Cows in the H UFA farms produced significantly less milkfat (205 vs 244 kg/cow, $P<0.05$) and protein (163 vs 182 kg/cow, $P<0.05$) per lactation, had lower milkfat (4.00 vs 4.82 %, $P<0.05$) and milk protein (3.15 vs 3.55 %, $P<0.05$) percentages, but had higher percentages of UFA (34.76 vs 30.32, $P<0.05$) and CLA (1.03 vs 0.94 %, $P<0.05$) in milkfat than cows in the L UFA farms. Although the difference was not significant, cows in the H UFA farms also tended to have lower feed demand per cow (4862 vs 5171 kg 5002

DM/year) than cows in the L UFA farms. There were no significant differences in milk yield (5260 vs 5214 L/lactation) and liveweight (511 vs 514 kg) between cows in the H and L UFA farms. Cash operating surplus per cow was lower in the High UFA farms than in the Low UFA farms (NZ$ 300 vs 531, P<0.05). These results indicate that if companies want to encourage the production of speciality milk a new payment system will need to be developed so that farm profitability is not affected due to losses in production of fat and protein.

INTRODUCTION

In New Zealand, the milk payment system is based on the amount of milkfat and milk protein produced on farm, with a penalty for milk volume (LIC, 2010). However, the composition of milkfat is also important because it influences the nutritive value and manufacturing characteristics of milk (Arsic *et al.*, 2009; Glantz *et al.*, 2009).

A trend in consumer demand for healthy and convenient dairy products has been observed in some countries in recent years (Wiley, 2007). The increase in obesity and other diseases associated with high intakes of saturated fatty acids (SFA) has resulted in a trend for low-fat foods. As a consequence, new markets have emerged for low-fat dairy products, functional dairy products and dairy products that are convenient to use.

The nutritive value and manufacturing characteristics of milk can be improved by increasing its concentration of unsaturated fatty acids (UFA), and decreasing its concentration of SFA. The replacement of dietary SFA with UFA has been associated with decreased risk for cardiovascular diseases and lower cholesterol concentration in plasma (Givens, 2008). Increasing the concentration of UFA in milkfat also increases the concentration of Conjugated Linoleic Acid (CLA), a fatty acid that has anticarcinogenic properties (Parodi, 1994). An additional benefit of increasing the concentration of UFA in milkfat is the increase in butter spreadability (Bobe *et al.*, 2003).

The concentration of UFA in milkfat is influenced by nutrition, genetics, stage of lactation, animal genotype, parity and energy status of the cow (Auldist *et al.*, 1998; Thomson & Van-der-Poel, 2000). Several studies have considered the inheritance of milkfat UFA concentration and its correlation with other milk production traits

(Arnould & Soyeurt, 2009; Schennink *et al.*, 2008; Soyeurt *et al.*, 2008; Stoop, 2009). These studies indicated that there is a negative relationship between the UFA concentration and the yields and percentages of milkfat and protein. For this reason, greater understanding of the consequences of selecting for increased milkfat UFA concentration is needed before implementing a breeding programme. Therefore, the objective of this research was to compare the characteristics of farms that produce milkfat with either a high or a low concentration of UFA under a seasonal pastoral system.

METHODOLOGY

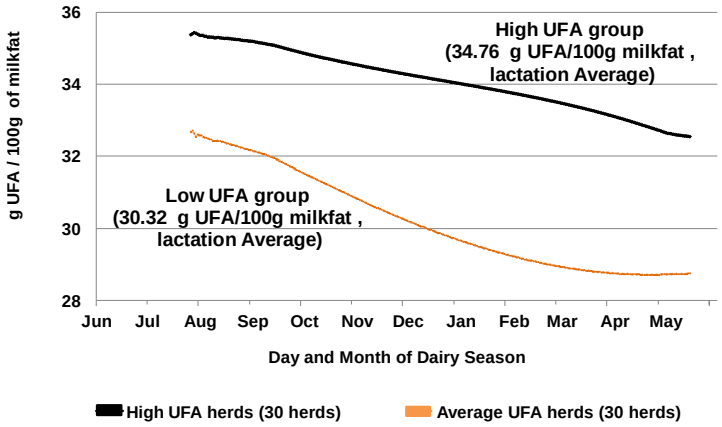
A stochastic simulation model based on a variance-covariance matrix of milk traits and liveweight was used to generate data for dairy farms. The variance-covariance matrix was derived using data from the New Zealand Holstein-Friesian strain trial (MacDonald et al., 2005). The model used the Wilmink function (Wilmink, 1987) for the simulation of milk yield, the percentages of milkfat and milk protein, and cow liveweight. To simulate the concentrations of UFA and CLA in milkfat the model used a third order orthogonal polynomial. Milkfat and milk protein yields were estimated from milk yield and the percentages of milkfat and milk protein, respectively. Feed demand per cow was estimated from energy requirements for maintenance, milk production, pregnancy and liveweight change using the equations developed by Rattray *et al*. (2007).

Two groups of herds were generated: 1) 30 high (H) UFA farms, and 2) 30 low (L) UFA farms. Each farm had 130 hectares, 351 cows, a spring calving period between 20th July and 10th October and a replacement rate of 18%. For each farm, it was assumed that pasture eaten per hectare per year equalled 10 tonnes of dry matter, with deficits in feed being filled with supplements. Confidence intervals (95%) for the high and low UFA group means were determined by bootstrapping methodology for which the simulation was replicated 100 times.

RESULTS

Throughout the dairy season, cows in the H UFA farms produced milkfat with significantly ($P<0.001$) higher UFA concentration than L UFA herds (Figure 1).

Figure 1: Concentration of Unsaturated Fatty Acids (UFA) in milkfat during the lactation in farms simulated to be high or low for concentration of Unsaturated Fatty Acids (UFA).



Cows in the H UFA farms had significantly lower yields and percentages of milkfat and milk protein, but higher CLA concentration in milkfat, than cows in the L UFA farms (Table 1). There were no significant differences in lactation length, milk yield and liveweight between cows in the H or L UFA farms.

Table 1: Mean and (95% confidence interval) for physical characteristics, per cow and per hectare, of farms simulated to be high or low for concentration of Unsaturated Fatty Acids (UFA) in milkfat.

Trait	High UFA farms 30 farms		Low UFA farms 30 farms		Significance
Per cow					
Lactation length (days)	275	(274 - 276)	275	(274 - 276)	NS
Litres milk/lactation	5260	(5016 - 5491)	5214	(4873 - 5475)	NS
kg milkfat/lactation	205	(196 - 214)	244	(230 - 255)	*
kg protein/lactation	163	(156 - 170)	182	(171 - 191)	*
% Fat	4.00	(3.89 - 4.12)	4.82	(4.67 - 4.97)	*
% Protein	3.15	(3.11 - 3.22)	3.55	(3.46 - 3.62)	*
g CLA/100g of milkfat	1.03	(0.99 - 1.06)	0.94	(0.91 - 0.97)	*
g UFA/100g of milkfat	34.76	(34.59- 34.91)	30.32	(29.76- 30.75)	*
kg liveweight	511	(498 - 520)	514	(498 - 525)	NS
kg dry matter demand	4862	(4727 - 4993)	5171	(4964 - 5326)	NS
Per hectare					
Stocking rate	2.70		2.70		
Litres milk	14201	(13544 - 14825)	14078	(13160 - 14781)	NS
kg fat	554	(530 - 577)	660	(620 - 688)	*
kg protein	441	(422 - 461)	491	(462 - 516)	*
Pasture supply (tDM)	10		10		
Supplement supply (tDM)	3.13	(2.76 - 3.49)	3.96	(3.42 - 4.39)	NS

Feed demand per cow tended to be lower for cows in the H UFA farms than cows in the L UFA farms, although the difference was not significant. These differences were also observed on a per hectare basis (Table 1).

Table 2: Mean and (95% confidence interval) corresponding to the financial characteristics, per cow and per hectare, of farms simulated to be high or low for concentration of Unsaturated Fatty Acids (UFA) in milkfat.

Trait	High UFA farms (34.76 UFA[1]) NZ $		Low UFA farms (30.32 UFA[1]) NZ $		Significance
Per cow					
Milkfat income [2]	956	(914 - 996)	1139	(1069 - 1186)	*
Milk protein income [2]	1143	(1095 - 1194)	1273	(1197 - 1336)	*
Volume penalty [2]	-210	(-219 - -201)	-209	(-220 - -196)	NS
Total milk income	1889	(1811 - 1969)	2204	(2070 - 2303)	*
Stock income	74	(72 - 75)	74	(72 - 75)	NS
Other income	14		14		
Gross farm income	1977	(1898 - 2057)	2292	(2158 - 2392)	*
Marginal expenses[3]	990		990		
Feed expenses[4]	687	(649 - 723)	771	(715 - 814)	NS
Farm expenses	1677	(1639 - 1713)	1761	(1705 - 1804)	NS
Cash Operating Surplus	300	(249 - 343)	531	(445 - 592)	*
Per hectare					
Milkfat income [2]	2582	(2467 - 2690)	3076	(2888 -3204)	*
Milk protein income [2]	3087	(2957 - 3226)	3437	(3233 - 3610)	*
Volume penalty [2]	-568	(-593 - -544)	-563	(-593 - -530)	NS
Total milk income	5101	(4888 - 5317)	5950	(5589 - 6218)	*
Stock income	199	(195 - 201)	199	(195 - 203)	NS
Other income	38		38		
Gross farm income	5338	(5125 - 5554)	6187	(5826 - 6458)	*
Marginal expenses[3]	2673		2673		
Feed expenses[4]	1854	(1753 - 1952)	2082	(1931 - 2198)	NS
Farm expenses	4527	(4426 - 4625)	4755	(4604 - 4871)	NS
Cash Operating Surplus	811	(673 - 926)	1432	(1201 - 1598)	*

[1] UFA: UFA concentration in g UFA/100g of milkfat

[2] Milk price: NZ$4.66/kg milkfat, NZ$7.00/kg protein and NZ$ -0.04/L.

[3] Marginal expenses: labour costs, health costs, breeding & herd improvement, farm dairy, electricity, young stock grazing, vehicles & fuel, repairs &maintenance, overheads.

[4] Feed costs of the milking herd. Comprises costs of pasture grown on farm (NZ$ 0.10/kg DM) and supplements fed (NZ$ 0.273/kg DM).

Milkfat income, milk protein income, total milk income and gross farm income, on a per cow and per hectare basis, were lower in the H UFA farms than in the L UFA

farms (Table 2). Although the difference was not significant, farms in the H UFA group had lower feed costs, per cow and per hectare, than farms in the L UFA group. On average, H UFA farms had a NZ$ 231 lower cash operating surplus/cow, and NZ$ 621 lower cash operating surplus/ha than L UFA farms.

DISCUSSION

This study reported the production characteristics of simulated herds of cows that produced milkfat with either high or low concentration of UFA in milkfat. The negative relationship between concentration of UFA in milkfat and the yields and percentages of milkfat and milk protein is consistent with what has been reported in the literature (Arnould & Soyeurt, 2009; Soyeurt & Gengler, 2008; Stoop *et al.*, 2008). The differences between the H and L farms in milksolids production (fat + protein) per cow and per hectare (58kg and 156kg, respectively) were associated with differences in cash operating surplus per cow and per hectare of NZ$ 231 and NZ$ 621, respectively. The H UFA farms simulated in the present study needed a premium of at least NZ$ 231/cow (NZ$ 3.98/kg milksolids) just to to break even with the L UFA farms. Differences in production and profit due to UFA concentration in milkfat can vary depending on animal, environmental and financial factors. However, an economic incentive will need to be offered by dairy processors so that farm profitability is not affected due to losses in production of fat and protein.

CONCLUSIONS

The results of this study indicated that high concentrations of UFA in milkfat were associated with lower in milkfat and milk protein yields and percentages per cow and per hectare. In New Zealand, under the current payment system (milkfat + milk protein – milk volume) the operating cash surplus was negatively affected in herds with high concentrations of UFA in milkfat. This study highlights the need for further research before implementing a programme for increasing the concentration of UFA in milkfat and the development of a payment system that rewards the concentration of UFA in milkfat.

ACKNOWLEDGEMENT

The authors acknowledge the financial contribution of the Institute of Veterinary, Animal and Biomedical Sciences (Massey University) and the Westpac Taranaki Agricultural Research Station (WTARS) towards this study.

REFERENCES

Arnould V. M. R., Soyeurt H. 2009: Genetic variability of milk fatty acids. *Journal of Applied Genetics, 50*(1), 29-39

Arsic A., Prekajski N., Vucic V., Tepsic J., Popovic T., Vrvic M., et al. 2009: Milk in human nutrition: Comparison of fatty acid profiles. *Acta Veterinaria-Beograd, 59*(5-6), 569-578

Auldist M. J., Walsh B. J., Thomson N. A. 1998: Seasonal and lactational influences on bovine milk composition in New Zealand. *Journal of Dairy Research, 65*(3), 401-411

Bobe G., Hammond E. G., Freeman A. E., Lindberg G. L., Beitz D. C. 2003: Texture of butter from cows with different milk fatty acid compositions. *Journal of Dairy Science, 86*(10), 3122-3127

Givens D. I. 2008: Session 4: Challenges facing the food industry in innovating for health: impact on CVD risk of modifying milk fat to decrease intake of SFA and increase intake of cis-MUFA. *Proceedings of the Nutrition Society, 67*(4), 419-427

Glantz M., Mansson H. L., Stalhammar H., Barstrom L. O., Frojelin M., Knutsson A., et al. 2009: Effects of animal selection on milk composition and processability. *Journal of Dairy Science, 92*(9), 4589-4603

LIC. 2010: *New Zealand Dairy Statistics 2008/09*. New Zealand. Livestock Improvement Corporation.48.

MacDonald K. A., Thorrold B. S., Glassey C. B., Holmes C. W., Pryce J. E. 2005: Impact of farm management decision rules on the production and profit of different strains of Holstein-Friesian dairy cows. 40-45.

Parodi P. W. 1994: Conjugated Linoleic Acid - An anticarcinogenic fatty acid present in milkfat. *Australian Journal of Dairy Technology, 49*(2), 93-97

Rattray P. V., Brookes I. M., Nicol A. M. 2007: *Pasture and supplements for grazing animals*. New Zealand Society of Animal Production (Occasional Publication No. 14).309.

Schennink A., Heck J. M. L., Bovenhuis H., Visker M., Van Valenberg H. J. F., Van Arendonk J. A. M. 2008: Milk fatty acid unsaturation: Genetic parameters and effects of stearoyl-CoA desaturase (SCD1) and acyl CoA : diacylglycerol acyltransferase 1 (DGAT1). *Journal of Dairy Science, 91*(5), 2135-2143

Soyeurt H., Dardenne P., Dehareng F., Bastin C., Gengler N. 2008: Genetic parameters of saturated and monounsaturated fatty acid content and the ratio of saturated to unsaturated fatty acids in bovine milk. *Journal of Dairy Science, 91*(9), 3611-3626

Soyeurt H., Gengler N. 2008: Genetic variability of fatty acids in bovine milk. *Biotechnologie Agronomie Societe Et Environnement, 12*(2), 203-210

Stoop, W. M. 2009: *Genetic variation in bovine milk fat composition*

Stoop W. M., Van Arendonk J. A. M., Heck J. M. L., Van Valenberg H. J. F., Bovenhuis H. 2008: Genetic parameters for major milk fatty acids and milk production traits of Dutch Holstein-Friesians. *Journal of Dairy Science, 91*(1), 385-394

Thomson N. A., Van-der-Poel W. 2000: Seasonal variation of the fatty acid composition of milkfat from Friesian cows grazing pasture. *Proceedings of fhe New Zealand Society of Animal Production, 60*, 314-317

Wiley A. S. 2007: Transforming Milk in a Global Economy. *American Anthropologist, 109*(4), 666-677

Wilmink J. B. M. 1987: Adjustment of test-day milk, fat and protein yield for age, season and stage of lactation. *Livestock Production Science, 16*(4), 335-348