Perspectives in Practice

Survey of Retail Milk Composition as Affected by Label Claims Regarding Farm-Management Practices

JOHN VICINI, PhD; TERRY ETHERTON, PhD; PENNY KRIS-ETHERTON, PhD, RD; JOAN BALLAM, MS; STEVEN DENHAM, PhD; ROBIN STAUB, PhD; DANIEL GOLDSTEIN, MD; ROGER CADY, PhD; MICHAEL McGRATH, PhD; MATTHEW LUCY, PhD

ABSTRACT

A trend in food labeling is to make claims related to agricultural management, and this is occurring with dairy labels. A survey study was conducted to compare retail milk for quality (antibiotics and bacterial counts), nutritional value (fat, protein, and solids-not-fat), and hormonal composition (somatotropin, insulin-like growth factor-1 [IGF-1], estradiol, and progesterone) as affected by three label claims related to dairy-cow management: conventional, recombinant bovine somatotropin (rbST)–free (processor-certified not from cows supplemented with rbST), or organic (follows US Department of Agriculture organic practices). Retail milk samples (n=334) from 48 states were collected. Based on a statistical analysis that reflected the sampling schema and distributions appropriate to the various response variables, minor differences were observed for conventional, rbST-free, and organic milk labels. Conventionally labeled milk had the lowest ($P<0.05$) bacterial counts compared to either milk labeled rbST-free or organic; however, these differences were not biologically meaningful. In addition, conventionally labeled milk had significantly less ($P<0.05$) estradiol and progesterone than organic milk (4.97 vs 6.40 pg/mL and 12.0 vs 13.9 ng/mL, respectively). Milk labeled rbST-free had similar concentrations of progesterone vs conventional milk and similar concentrations of estradiol vs organic milk. Concentrations of IGF-1 in milk were similar between conventional milk and milk labeled rbST-free. Organic milk had less ($P<0.05$) IGF-1 than either conventional or rbST-free milk (2.73 ng/mL vs 3.12 and 3.04 ng/mL, respectively). The macronutrient profiles of the different milks were similar, except for a slight increase in protein in organic milk (about 0.1% greater for organic compared to other milks). Label claims were not related to any meaningful differences in the milk compositional variables measured. It is important for food and nutrition professionals to know that conventional, rbST-free, and organic milk are compositionally similar so they can serve as a key resource to consumers who are making milk purchase (and consumption) decisions in a marketplace where there are misleading milk label claims.
J Am Diet Assoc. 2008;108:1198-1203.

J. Vicini is a senior research fellow, J. Ballam is lead for biostatistics and data services, R. Staub is lead for molecular and cellular biochemistry, D. Goldstein is director of medical toxicology, R. Cady is technical product manager, and M. McGrath is senior lactation physiologist, all at Monsanto Company LC, St Louis, MO. T. Etherton is a distinguished professor of animal nutrition and P. Kris-Etherton is a distinguished professor of nutrition, both at The Pennsylvania State University, University Park. S. Denham is associate director of biostatistics, MPI Research, Mattawan, MI. At the time of the study he was senior statistician, Monsanto Company LC, St Louis, MO. M. Lucy is professor of animal sciences, University of Missouri, Columbia.

Address correspondence to: John Vicini, PhD, Monsanto Company LC, 800 N Lindbergh Blvd, St Louis, MO 63167. E-mail: john.l.vicini@monsanto.com

Manuscript accepted: January 29, 2008.

0002-8223/08/10807-0005$34.00/0
doi: 10.1016/j.jada.2008.04.021

Some milk processors make label claims that describe management of cows at dairy farms. These claims include the practice of grazing or the nonuse of pesticides or antibiotics. Absence-claim labels can imply to some consumers that the labeled milk is safer or better vs nonlabeled milk because most consumers have little knowledge of how milk is produced, processed, and distributed to retail stores. Consumers need to be mindful about how product labels impact the food they purchase based on science and not on perceptions created by retail marketing. Food and nutrition professionals, as a major source of information to consumers, are in an important position to convey science-based facts about foods.

Recently, a new niche in the dairy case is milk labeled as free of recombinant bovine somatotropin (rbST). bST is a protein produced by the pituitary gland and is an important regulator of lactation in the cow (and other mammals). Circulating concentrations of bST are correlated positively with the level of milk production (1,2). Commercial use of rbST was approved by the US Food and Drug Administration in 1993 for increasing milk production based on scientific evidence collected to assess safety to cows and consumers (3,4). Supplementation with rbST involves biweekly subcutaneous injections beginning in the 9th or 10th week of lactation, which is after cows have reached peak daily milk production, and milk production and circulating bST decline. The US Food and Drug Ad-

ministration also evaluated milk from cows supplemented with rbST and these studies demonstrated that nutritional composition and manufacturing properties were not altered (5). Additional studies [extensively reviewed in (3)] in animal and cell culture systems concluded that milk from cows supplemented with rbST is safe for consumers (3,6).

For food and nutrition professionals to effectively respond to consumer questions and perceptions about different milk-label claims, they must understand whether the nutrient composition or amounts of other analytes found in retail milk with various management labels differ. It is reasonable to conclude that management labels are not predictive of milk composition for the following reasons: previous studies indicate that rbST does not alter milk composition; diversity of management practices between farms, dairy breeds, and stage of lactation has a greater impact on milk composition; and milk sold at retail is pooled from multiple dairy farms. However, surprisingly little data are available that compare measurements of quality, nutrient, and hormonal composition of milk by three retail labels related to dairy-farm management. Thus, the objective of this study was to compare these endpoints for conventional, rbST-free, and organic milk.

METHODS

Sampling Methods

Milk samples from stores in the 48 contiguous states within the United States were obtained. Samples were purchased in blocks containing three label types to minimize effects of shipping conditions. A block consisted of a shipping container collected on one day, by one sampler, and in one city. The target was to sample each state with two complete blocks of samples, and to oversample those states that had larger populations or greater amounts of milk production in order to more accurately represent the milk supply of the United States. Samples were obtained during 3 weeks in October and November 2006. Supplies and procedures for shipping milk were standardized for all samples. Sample collectors were employees of the Monsanto Company living in each state.

Milk was purchased in blocks that consisted of one each of the following label types: conventional, rbST-free, or organic milk. Conventionally labeled milk was retail milk that did not contain any claims about rbST supplementation or organic production practices. Milk labeled as rbST-free is a processor claim that cows were not supplemented with rbST and could not be verified for this study. Milk labeled as organic comes from farms that were certified to meet US Department of Agriculture organic standards. Stores were selected to maximize the opportunity to locate all milk samples within the same store, and store was not a factor tested in the study. Samples were selected using the following preferences: whole milk, freshest milk based on expiration date, paper or plastic container, and any retail brand could be sampled with the expectation that not all label types were the same brand of milk. Samplers made an effort to locate all milk types but if, after visiting three stores in which they could not locate one milk type, then remaining samples were purchased and the block was incomplete. All milk was pasteurized. To avoid confounding because of the method of pasteurization, milk labeled as processed using ultra-high temperature pasteurization was not used. After purchase, milk containers were sealed and shipped on ice by overnight mail to St Louis. Receipt of samples, aliquotting, and transfer to laboratories was audited by an independent auditing firm (Pharmaceutical Services Corporation, Austin, TX).

Assays

Milk Quality. Samples were analyzed for antibiotics and bacterial counts at Dairy One Cooperative, Inc (Ithaca, NY). Delvotest P 5 Pack (DSM Food Specialties, Eagleville, PA), and Charm SL Beta-lactam Test (Charm Sciences, Inc, Lawrence, MA) kits were used for antibiotics. Samples also were tested for bacterial counts using the standard plate count method. Samples were streaked on Petrifilm Aerobic Count plate (3M, St Paul, MN) and colonies were counted at 48 hours.

Nutrients. Fat, protein, total solids, solids-not-fat, and other solids were analyzed using a Milkoscan 4000 (Foss, Eden Prairie, MN) at Dairy One, Inc.

Hormones. Progesterone and estradiol were analyzed by radioimmunoassay at University of Missouri (Columbia, MO). Concentrations of progesterone in milk were analyzed using a kit (Coat-A-Count; Diagnostic Products Corp, Los Angeles, CA) that was validated for bovine milk. Assay sensitivity was 0.1 ng/mL and intra and inter-assay coefficients of variation were 6% and 2%.

Milk estradiol was measured by a validated radioimmunoassay using a modification of the procedure described by Kirby and colleagues (7), in which samples were extracted with ethyl acetate (Fisher Scientific, Fairlawn, NJ). Assay sensitivity was 0.78 pg/mL and intra and inter-assay coefficients of variation were 18% and 19%.

Milk insulin-like growth factor-1 (IGF-1) and bST concentrations were determined by electrochemiluminescent immunoassays using a Sector Imager 6000 (Meso Scale Discovery, Gaithersburg, MD) at Monsanto (8).

Statistical Analyses

All variables were analyzed with models that accounted for the fixed effects of label type, milk-fat content (whole, reduced fat) and the interaction of label type and milk-fat content (SAS, SAS Institute Inc, Cary, NC, version 9.1.3, 2006). Shipping box was fit as a random block effect in all models. When analyzing bacterial counts, a covariate adjustment was made to account for the time between each sample's assay and expiration dates. Statistical analyses were performed using data from whole and reduced-fat milk samples; however, least-squares means reported in the tables are for whole milk only, as $<8\%$ of the samples were reduced-fat milk. P values reported in the tables are for the test of a difference among label types using both milk-fat levels. Least-squares means within whole milk

Table 1. Least-squares means for concentrations of nutrients and bacterial counts in retail milk with labels related to three types of dairy-farm management

	Retail Milk Label[a]			
	Conventional	rbST-free	Organic	*P* value
	← *least-squares mean ± standard error* →			
Bacterial counts (1,000 cfu/mL)[b]	11±4.0[x]	26±9.7[y]	22±8.1[z]	0.0001
Fat (%)	3.30±0.022	3.38±0.026	3.38±0.024	0.488
Lactose (%)	4.71±0.014	4.70±0.017	4.67±0.015	0.155
Protein (%)[c]	3.14±0.012[x]	3.15±0.014[x]	3.22±0.012[y]	0.001
Total solids (%)	12.07±0.034	12.16±0.041	12.20±0.036	0.189
Solids-not-fat (%)[d]	8.77±0.021	8.77±0.026	8.82±0.023	0.010
Other solids (%)	5.63±0.013	5.62±0.015	5.60±0.014	0.149

[a]Conventionally labeled milk: did not contain any claims about supplementation with recombinant bovine somatotropin (rbST) or organic production practices. rbST-free: processor claim that cows were not supplemented with rbST. Organic: milk from farms that were certified to meet US Department of Agriculture organic standards.
[b]Statistical differences are based on standard errors of the differences between label types. Reported standard errors are for the least-squares means and not the differences between least-squares means.
[c]Protein analysis was for true protein ((total nitrogen−nonprotein nitrogen)×6.38).
[d]A difference between label types was found ($P=0.010$) over all milk fat contents; however, within the whole-milk samples there was no significant difference.
[xyz]Values with different superscripts are different ($P<0.05$) within whole milk.

Table 2. Least-squares means for concentrations of hormones in retail milk with labels related to three types of dairy-farm management

	Retail Milk Label[a]			
	Conventional	rbST-free	Organic	*P* value
	← *least-squares mean ± standard error* →			
Bovine somatotropin (ng/mL)[b]	0.005±0.0024[c]	0.042±0.0122	0.002±0.0014[c]	0.098
Insulin-like growth factor-1 (ng/mL)	3.12±0.059[y]	3.04±0.070[y]	2.73±0.061[z]	0.001
Progesterone (ng/mL)	12.0±0.39[y]	12.8±0.46[y]	13.9±0.44[z]	0.019
Estradiol (pg/mL)	4.97±0.239[y]	6.63±0.301[z]	6.40±0.274[z]	0.045

[a]Conventionally labeled milk: did not contain any claims about supplementation with recombinant bovine somatotropin (rbST) or organic production practices. rbST-free: processor claim that cows were not supplemented with rbST. Organic: milk from farms that were certified to meet US Department of Agriculture organic standards.
[b]Approximately 82% of the bovine somatotropin values were less than the limit of quantitation (0.033 ng/mL) and 72% were less than the limit of detection (0.010 ng/mL) for the assay. Individual values (x) used the following rules: if $x<0.010$ then set to 0; if $0.010<x<(0.5*0.033)$ then set to 0.0165; all other values were unchanged.
[c]Least-squares mean is less than assay limit of detection.
[yz]Values with different superscripts are different ($P<0.05$) within whole milk.

samples were compared using a protected least significant difference and only values with $P<0.05$ are reported as different.

RESULTS

Conventionally labeled retail milk samples were obtained from all 48 contiguous states. Milk samples labeled rbST-free were not located in Arkansas, Idaho, Indiana, Mississippi, Ohio, Oklahoma, South Dakota, Tennessee, and Wyoming. Similarly, organic milk samples, which were pasteurized by the more conventional, lower-temperature methods, were not obtained in Lousiana, Maine, and Mississippi.

Milk Quality

None of the milk samples had any detectable antibiotics based on either of the commercial kits utilized. There were significant differences for bacterial counts between all milk label types. Counts were the least for conventional milk, greatest for milk labeled as rbST-free, and intermediate for organic milk (Table 1).

Nutrients

There were no differences in milk fat, lactose, or solids among the three label types (Table 1); however, protein from organic milk (3.22%) was greater ($P<0.05$) than conventional (3.14%) or rbST-free milk (3.15%).

Hormones

There were no differences in concentration of bST in milk regardless of label type (Table 2). Concentrations of bST that were detectable in milk were very low and averaged 0.005 ng/mL. Concentrations of IGF-1 in conventionally labeled milk and milk labeled as rbST-free were 3.12 and 3.04 ng/mL, respectively; these values were not different. Organic milk averaged 2.73 ng/mL, which was less ($P<0.05$) than milk with the other labels.

The concentration of progesterone was greater ($P<$

0.05) in organic milk (13.9 ng/mL) compared to conventionally labeled (12.0 ng/mL) or milk labeled rbST-free (12.8 ng/mL). Similarly, conventionally labeled milk had less ($P<0.05$) estradiol (4.97 g/mL) compared to organic milk (6.40 pg/mL) and rbST-free milk (6.63 pg/mL), but concentrations of estradiol in samples labeled organic and rbST-free were not different.

DISCUSSION

Antibiotics were not detectable in any milk samples. This is not surprising because every bulk milk tanker is sampled and analyzed for antibiotic residue before milk is processed and sold. Milk containing antibiotics is not permitted to enter the food system and tankers testing positive are rejected for human consumption. During fiscal year 2006, over 3 million samples were analyzed from tankers and approximately 1,000 (0.038%) tested positive (9).

Although milk is pasteurized, it is not a sterile product and the federal limit for bacterial counts following pasteurization is 20,000 cfu/mL. Bacterial counts were less for conventionally labeled milk compared with organic or rbST-free milk. Although statistically different, these differences in bacterial counts are small and one should not infer that the greater bacterial counts of rbST-free milk indicate a meaningful biological difference in milk quality. Another measurement that reflects milk quality is somatic cell count, which was not measured in this study because pasteurization and homogenization disrupt somatic cells; hence, somatic cell count is not reflective of raw milk values (10). Most somatic cells are white blood cells in the milk with a smaller fraction from sloughed mammary epithelial cells that are from normal cell turnover. A previous survey indicated that somatic cell count was greater in organic vs conventional herds (11). This may be the result of facilities or organic farming practices. In the survey by Zwald and colleagues (11), organic farms had smaller herd sizes and did more milking in tie-stall or stanchion barns. These types of facilities are more limited in types of milking hygiene practices. While organic methods specify that therapeutic treatments should not be withheld from sick or injured animals, there is an economic incentive for organic dairies to milk high somatic cell count (a biomarker of mastitis) cows for longer periods prior to medical treatment.

In large part, there were no effects of milk-label type on nutrient composition. Nutritional management of dairy cows can markedly affect fat concentrations in the milk of individual cows. However, changes in fat content of retail milk would be unexpected, even with substantial changes in management practices, because the concentration of fat in retail milk is adjusted by milk processors. Whole milk is defined as containing not less than 3.25% fat and 8.25% solids-not-fat.

Protein concentration was greater in organic milk compared to either conventional or rbST-free milk. This difference could be a result of processor manipulation or farm management. Possible farm-management effects that could be responsible for greater protein percent of milk are: a greater proportion of milk from the Jersey breed compared to Holstein cows; less reliance on fat supplementation of the cows' diets; or lower-producing cows typically have a greater concentration of protein in milk, and cows managed in an organic system are usually lower producing than those managed by conventional management (10,12). Regardless of the source of the difference, it accounts for little (<0.5%) of the recommended protein intake for humans (13). Protein content was similar between conventionally labeled milk and milk labeled as rbST-free. Milk fat, solids, protein, macro- and micronutrients, and proportions of specific proteins (eg. casein, lactalbumin) and fatty acids were unaffected by bST supplementation (5).

Concentrations of bST in milk were not affected by the type of milk label. There are several reasons why supplementing cows with bST does not alter bST content of milk. First, the mammary gland is not a target for bST and there are no receptors for bST on the mammary gland (14), therefore, bST is not actively secreted into milk. Second, most of the bST in milk is denatured by pasteurization (15). In addition to the lack of change in milk concentration, bST does not have biological effects in humans. Because bST is a protein, it is digested in the gastrointestinal tract to amino acids and peptides that do not have hormonal activity. Moreover, humans do not respond to bST whether administered orally or parentally (16) because the amino acid sequence of human and bovine somatotropin differs by approximately 35% (3). Because of this difference, nonprimate somatotropin, like bST, does not bind to the human receptor (17,18), which is necessary for biological effects.

Concentrations of IGF-1 in milk were similar in conventional and rbST-free milk. Circulating IGF-1 was elevated in cows treated with rbST and some, but not all, studies have shown an increase in IGF-1 in milk of treated cows (4). Unlike bST, the amino acid sequences of human and bovine IGF-1 are identical. However, IGF-1 is a protein that is degraded in the digestive tract and is not absorbed intact. Based on slight increases in circulating IGF-1 in the cow due to rbST-supplementation, if IGF-1 survived digestion and was absorbed intact, adults would need to consume 150 L/day of milk to equal the amount of IGF-1 normally secreted within just the upper gastrointestinal tract of humans. More important, retail milk is pooled from all cows and the concentration of IGF-1 is actually greater in milk from early lactation cows (19), which are not supplemented with rbST and averaged 6 ng/mL.

Conventional milk and milk labeled rbST-free had slightly more IGF-1 compared to organic milk. One factor that might account for this difference is the potential inclusion of organic ultrapasteurized milk in this survey. Milk samples were surveyed to determine if labels related to farm management affected milk composition. Samples known to be raw milk or milk that was ultrapasteurized were not included in the analysis. Including ultrapasteurized milk in this survey could confound interpretation of results, especially if milk from one label type had a disproportionate use of ultrapasteurized relative to other label types. Traditional pasteurization methods do not denature IGF-1, but greater temperatures, such as those used for infant formula, do denature IGF-1 (20). Organic milk from some locations was not included because only ultrapasteurized organic milk was available. Some retailers do not put the method of pasteurization on the label because the only label requirement is that pasteurized

milk be labeled as pasteurized, but the method of pasteurization is not required (21). So, despite efforts to avoid it, there could be ultrapasteurized milk included in the survey. If so, it would be reasonable to conclude that most of these would be in the organic group because little, if any, commercial nonlabeled milk is processed using ultrapasteurization. This could explain the slight reduction in IGF-1 concentration in organic milk reported.

Another reason the concentration of IGF-1 may have been less in milk labeled as organic is that circulating IGF-1 can be decreased in lactating cows by reducing energy and/or protein balance. In one study, plasma IGF-1 concentration of cows from organic farms was less than for cows from integrated farms, and this difference was attributed to lower protein and energy consumption (22). While these results are reasonable, further studies are needed to confirm if organic milk is actually lower in IGF-1. Nonetheless, to put this in perspective, the differences observed in this survey amounts to only 0.003% of the IGF-1 produced daily in humans.

Concentrations of the steroid hormones, estradiol and progesterone, were lowest for conventional milk and greatest for organic milk. Milk labeled as rbST-free had similar concentrations of estradiol compared to organic milk and similar concentrations of progesterone compared to conventionally labeled milk. These results may be due to level of feed intake. Sangsritavong and colleagues (23) hypothesized that cows with greater feed consumption had an increased clearance of steroid hormones by the liver, which reduces circulating estradiol concentrations. Because steroids are low-weight lipophylic molecules capable of passing through membranes, the concentration in milk is correlated to circulating concentrations. Therefore, the greater feed consumption of conventionally managed cows compared to organic cows could explain the reduced steroid concentrations in conventional milk. Other farm factors known to influence concentrations of estrogen in milk are stages of lactation and pregnancy (24). Concentrations of estrogen and progesterone are not affected by conventional pasteurization methods and concentrations in milk are greater in milk products with more fat (24,25). In spite of these differences, concentrations of estradiol and progesterone are low compared to endogenous production in humans (24).

One difference that is affected by the management label on milk is price. Milk labeled rbST-free or organic is up to $1.00 or $4.00 more per gallon than conventional milk, respectively. Affordability of milk influences milk consumption of low-income consumers, a cohort for which milk is most needed. Dairy farmers often have only one choice of a single dairy processor to sell their milk. The dairy processor then provides milk pooled from their farmer customers to retailers. When the processor does not accept milk from rbST-supplemented cows, only the higher-priced milk is available to the consumer. There is a growing database demonstrating many health benefits associated with dairy product consumption. It has long been recognized that dairy consumption favorably affects bone health (26). More recent findings are showing benefits of dairy consumption on body weight (27,28), type 2 diabetes (29), and blood pressure (30). Thus, reducing or eliminating dairy from the diet is associated with an increased health risk burden. Food and nutrition professionals need to be aware that all milk is the same compositionally within a fat class so that they can respond to consumer questions about milk labels. Consumer knowledge also is important so that they can make informed purchase decisions about milk based on science, not marketing label claims.

CONCLUSIONS

Results of this study indicate that there are few and minor differences in the composition of conventional, rbST-free, or organic labeled milk, and that all milk is wholesome. These conclusions are based on specific analytes that represent milk quality and nutrients and hormones found in all milk. It is important to appreciate that rbST use does not affect milk composition, and that all milk (ie, conventional, rbST-free, and organic) is compositionally similar. Food and nutrition professionals are well-positioned to communicate this information to the public.

Funding for this study was provided by Monsanto Company, LC.

References

1. Hart IC, Bines JA, Morant SV, Ridley JL. Endocrine control of energy metabolism in the cow: Comparison of the levels of hormones (prolactin, growth hormone, insulin and thyroxine) and metabolites in the plasma of high- and low-yielding cattle. *J Endocrinol.* 1978;77:333-345.
2. Weber WJ, Wallace CR, Hansen LB, Chester-Jones H, Crooker BA. Effects of genetic selection for milk yield on somatotropin, insulin-like growth factor-I and placental lactogen in Holstein cows. *J Dairy Sci.* 2007;90:3314-3325.
3. Juskevich JC, Guyer CG. Bovine growth hormone: Human food safety evaluation. *Science.* 1990;249:875-884.
4. World Health Organization. Toxicological evaluation of certain veterinary drug residues in food. *WHO Food Additives Series.* 1998;41:125-146.
5. Barbano DM, Lynch JM, Bauman DE, Hartnell GF, Hintz RL, Nemeth MA. Effect of a prolonged-release formulation of n-methionyl bovine somatotropin (sometribove) on milk composition. *J Dairy Sci.* 1992;75:1775-1793.
6. McGrath MF, Eppard PJ, Sweeny CA, Keller PG, Collier RJ. Proliferative activity of bovine milk following sometribove (methionyl-bovine somatotropin, rbST) administration. *J Dairy Sci.* 1993;76(suppl 1):170.
7. Kirby CJ, Smith MF, Keisler DH, Lucy MC. Follicular function in lactating dairy cows treated with sustained-release bovine somatotropin. *J Dairy Sci.* 1997;80:273-285.
8. McGrath MF, Fabellar AC, Staub RL, Widger LA, Bogosian G, Vicini, JL. Measurement of bST and IGF-1 in milk using electrochemiluminescent assay. *J Agric Food Chem.* In press.
9. US Food and Drug Administration. National milk drug residue data base fiscal year 2006 annual report. http://www.cfsan.fda.gov/~acrobat/milkrp06.pdf. Posted February 14, 2007. Accessed July 18, 2007.
10. Boor KJ. Fluid dairy product quality and safety: Looking to the future. *J Dairy Sci.* 2001;84:1-11.
11. Zwald AG, Ruegg PL, Kaneene JB, Warnick LD, Wells SJ, Fossler C, Halbert LW. Management practices and reported antimicrobial usage on conventional and organic dairy farms. *J Dairy Sci.* 2004;87:191-201.
12. Hardeng F, Edge VL. Mastitis, ketosis, and milk fever in 31 organic and 93 conventional Norwegian dairy herds. *J Dairy Sci.* 2001;84:2673-2679.
13. US Department of Agriculture. *Dietary Guidelines for Americans*. Washington, DC: US Department of Health and Human Services; 2005.
14. Akers RM. Lactogenic hormones: Binding sites, mammary growth, secretory cell differentiation, and milk biosynthesis in ruminants.*J Dairy Sci.* 1985;68:501-519.
15. Groenewegen PP, McBride BW, Burton JH, Elsasser TH. Bioactivity of milk from bst-treated cows. *J Nutr.* 1990;120:514-520.

16. Raben MS. Human growth hormone. *Rec Prog Horm Res.* 1959;15:71-105.
17. Souza SC, Frick GP, Wang X, Kopchick JJ, Lobo B, Goodman HM. A single arginine residue determines species specificity of the human growth hormone receptor. *Proc Natl Acad Sci.* 1995;92:959-963.
18. Liu JC, Makova KD, Adkins RM, Gibson S, Li WH. Episodic evolution of growth hormone in primates and emergence of the species specificity of human growth hormone receptor. *Mol Biol Evol.* 2001;19:945-953.
19. Collier RJ, Miller MA, Hildebrandt JR, Torkelson AR, White TC, Madsen KS, Vicini JL, Eppard PJ, Lanza GM. Factors affecting insulin-like growth factor-I concentration in bovine milk. *J Dairy Sci.* 1991;74:2905-2911.
20. Miller MA, Hildebrandt JR, White TC, Hammond BG, Madsen KS, Collier RJ. Determination of insulin-like growth factor-I (IGF-1) concentrations in raw, pasteurized, and heat-treated milk. *J Dairy Sci.* 1989;72(suppl):186.
21. *Grade "A" Pasteurized Milk Ordinance*. Washington, DC: US Department of Health and Human Services, Public Health Service, Food and Drug Administration; 2003:7-13.
22. Roesch M, Doherr MG, Blum JW. Performance of dairy cows on Swiss farms with organic and integrated production. *J Dairy Sci.* 2005;88:2462-2475.
23. Sangsritavong S, Combs DK, Sartori R, Wiltbank MC. High feed intake increases blood flow and metabolism of progesterone and estradiol-17β in dairy cattle. *J Dairy Sci.* 2002;85:2831-2842.
24. Pape-Zambito DA, Magliaro AL, Kensinger RS. Concentrations of 17β-estradiol in Holstein whole milk. *J Dairy Sci.* 2007;90:3308-3313.
25. Ginther OJ, Nuti LC, Garcia MC, Wentworth BC, Tyler WJ. Factors affecting progesterone concentration in cow's milk and dairy products. *J Anim Sci.* 1976;42:155-159.
26. Miller GD, Jarvis JK, McBean LD. *Handbook of Dairy Foods and Nutrition*. 3rd ed. Boca Raton, FL: CRC Press; 2007.
27. Pereira MA, Jacobs DR Jr, Van Horn L, Slattery ML, Kartashov AI, Ludwig DS. Dairy consumption, obesity, and the insulin resistance syndrome in young adults: The CARDIA Study. *JAMA.* 2002;287:2081-2089.
28. Snijder MB, van der Heijden AA, van Dam RM, Stehouwer CD, Hiddink GJ, Nijpels G, Heine RJ, Bouter LM, Dekker JM. Is higher dairy consumption associated with lower body weight and fewer metabolic disturbances? The Hoorn Study. *Am J Clin Nutr.* 2007;85:989-995.
29. Choi HK, Willett WC, Stampfer MJ, Rimm E, Hu FB. Dairy consumption and risk of type 2 diabetes mellitus in men: A prospective study. *Arch Intern Med.* 2005;165:997-1003.
30. Steffen LM, Kroenke CH, Yu X, Pereira MA, Slattery ML, Van Horn L, Gross MD, Jacobs DR Jr. Associations of plant food, dairy product, and meat intakes with 15-y incidence of elevated blood pressure in young black and white adults: The Coronary Artery Risk Development in Young Adults (CARDIA) Study. *Am J Clin Nutr.* 2005;82:1169-1177.