Symposium sur les bovins laitiers

du CRAAQ

Mardi
29 octobre
2019

Centrexpo Cogeco Drummondville

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Centre de référence en agriculture
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Symposium sur les bovins laitiers

Le mardi 29 octobre 2019

Centrexpo Cogeco Drummondville

Programme

Déjeuner-conférence

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Annie Royer, Ph.D. Sciences économiques, professeure agrégée au Département d'économie agroalimentaire et des sciences de la consommation, Université Laval

Symposium

Lactanet
RÉSEAU CANADIEN POUR L'EXCELLENCE LAITIÈRE

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Symposium sur les bovins laitiers

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Résumés des affiches

AFFICHE

Une fléole des prés avec un meilleur regain, est-ce possible ?

Annie Claessens[1], François langevin[1], Annick Bertrand[1], Solen Rocher[1], Gaëtan Tremblay[1] et Édith Charbonneau[2]

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La fléole des prés est la graminée fourragère la plus cultivée au Québec en raison de son rendement annuel élevé, son excellente valeur nutritive et de sa rusticité. Cependant, elle est sensible à la sécheresse et la chaleur, ce qui pourrait diminuer drastiquement sa productivité dans un contexte de changement climatique. Nous avons donc mis sur pied une étude visant à évaluer des cultivars provenant de 19 pays, et à identifier du matériel génétique ayant un bon potentiel de regain sous nos conditions environnementales actuelles.

Une large variabilité du rendement en matière sèche a été observée à la première et deuxième coupe parmi les 82 cultivars à l'étude (entre 4,3 et 8,5 tonnes de matière sèche (MS)/ha pour la coupe 1 et entre 1,0 et 2,6 tonnes MS/ha pour la coupe 2). Les cultivars de fléole des prés de type tardif se démarquaient des cultivars de type intermédiaire et hâtif par un rendement supérieur à la première coupe (7,2, 6,4 et 5,3 tonnes MS/ha, respectivement), alors que l'ensemble des cultivars avait un rendement équivalent à la deuxième coupe (1,5, 1,8 et 1,9 tonne MS/ha, respectivement). Parmi tous les plants de l'étude, 184 plants ont démontré une bonne vigueur de regain. Ils ont été groupés par type de maturité puis croisés afin de développer de nouvelles populations. Comme pour les cultivars, les populations de type tardif ont donné un rendement supérieur à la première coupe et plus faible à la deuxième coupe que les populations de type hâtif. Cette étude a permis d'identifier des plants de fléole des prés à maturité tardive ayant un rendement supérieur à la fois en première et en deuxième coupe. Ces plants serviront de matériel génétique pour développer de nouveaux cultivars qui seront éventuellement offerts aux producteurs laitiers du Québec.

Ce projet a été financé par Agriculture et Agroalimentaire Canada en collaboration avec le FRQNT-MAPAQ-Novalait.

AFFICHE

Une luzerne plus sucrée pour vos vaches laitières?

Annie Claessens, Annick Bertrand, Solen Rocher et Marie-Noëlle Thivierge

Agriculture et Agroalimentaire Canada - Centre de Recherche et de Développement de Québec - 2560, boul. Hochelaga, Québec (QC) G1V 2J3. Canada

Les vaches nourries de fourrages plus riches en sucre ont une meilleure efficacité d'utilisation de l'azote et une production de lait plus élevée. Cependant, ce caractère est fortement influencé par plusieurs facteurs (environnement, stade de développement), ce qui complexifie la sélection de plantes et la création de variétés ayant une plus grande concentration en sucre. Notre équipe a donc proposé un critère de sélection basé sur la concentration en sucre dans les tiges de luzerne. Après trois cycles de sélection, nous avons développé une population de luzerne 8% plus riche en sucre comparativement à la population initiale. Nous avons aussi démontré que ce caractère était stable quel que soit le stade de développement ou la date de coupe. Ces populations seront évaluées au champ à travers le Canada de 2020 à 2022 et serviront de matériel génétique pour développer de nouveaux cultivars de luzerne plus riches en sucres, et mieux adaptés aux besoins des producteurs laitiers du Québec.

Ce projet a été co-financé par Agriculture et Agroalimentaire Canada et les Producteurs laitiers du Canada dans le cadre de la Grappe de recherche laitière.

AFFICHE

Les bactériocines : une alternative aux antibiotiques pour le traitement de la mammite ?

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Le recours aux antibiotiques pour le traitement et la prévention des mammites cliniques a certes permis de contrôler cette maladie et de réduire son incidence en élevage. Cependant, l'utilisation répandue de ces antibiotiques a entrainé l'apparition de microorganismes pathogènes multi-résistants qui représentent de nos jours une grave menace pour la santé humaine et animale. Par conséquent, le développement d'alternative aux antibiotiques est devenu urgent pour le secteur laitier. Les bactériocines sont des peptides antimicrobiens naturels synthétisés par une grande variété de bactéries et inhibant la croissance d'autres microorganismes dans leurs environnements. L'activité inhibitrice de différentes bactériocines a été évaluée chez des bactéries isolées de cas de mammite bovine. Nos travaux montrent que la bactofencine, la nisine et la réutérine peuvent prévenir la croissance de la plupart des bactéries, ce qui suggère que ces molécules naturelles sont de potentielles alternatives aux antibiotiques. Les prochaines étapes seront d'évaluer l'innocuité des bactériocines pour les vaches laitières et tester leur efficacité pour la prévention et le traitement de la mammite bovine.

Les auteurs aimeraient remercier Novalait, OP+lait et la chaire de recherche Metabiolac pour leur support financier dans ce projet.

AFFICHE

Intéressant de repousser la période d'attente volontaire chez les vaches en déficit énergétique de 60 à 120 jours post-partum?

Catherine Couture[1], Véronique Ouellet[1], Débora Santschi[2], Yasmin Schuermann[2], Victor Cabrera[3], René Roy[2], Marc-André Sirard[1] et Édith Charbonneau[1].

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Les vaches en début lactation sont souvent en déficit énergétique puisque leur consommation d'aliments ne leur permet pas de combler les besoins énergétiques nécessaires pour la production laitière. Cet état physiologique est associé à une augmentation de la mobilisation des gras comme source d'énergie se traduisant, entre autres, par une augmentation des ß-Hydroxybutyrate (BHB) dans le lait. Pour maximiser le profit des producteurs, il est pratique courante de suggérer de réduire l'intervalle entre deux vêlages grâce à une période d'attente volontaire avant la première saillie d'environ soixante jours après le vêlage. Ceci fait en sorte que la première saillie est effectuée lorsque les vaches sont encore en déficit énergétique ce qui peut ultimement avoir des répercussions négatives sur la vache, mais également sur son embryon. L'objectif de cette étude était de vérifier l'impact économique d'augmenter la période d'attente volontaire à plus de 100 jours pour les vaches ayant une teneur en BHB élevé dans le lait (bilan énergétique négatif) au premier contrôle de production. Les troupeaux laitiers à l'étude dénombraient en moyenne 20% de vaches en déficit énergétique le jour du premier contrôle. L'analyse économique par budget partiel indique qu'augmenter la période d'attente volontaire pour les vaches en déficit énergétique en début lactation n'entraîne pas d'impact sur le bénéfice net des fermes laitières. En effet, la perte encourue par la production laitière serait compensée par une légère augmentation des composants laitiers et par une diminution du taux de réforme, du nombre de saillies, des frais d'alimentation et des frais vétérinaires. Afin de produire le quota détenu, deux scénarios ont été analysés, soit le quota constant (achat de vache) ou le troupeau constant (vente de quota). Les résultats étaient similaires pour les deux scénarios. Ainsi, sachant qu'il n'y a pas d'inconvénient économique, il devient intéressant d'utiliser une stratégie de reproduction différente, notamment en retardant la première insémination, pour les vaches avec un taux de BHB élevé dans le lait le jour du premier contrôle de production considérant que cela pourrait entraîner des effets positifs sur l'embryon à naître. Ce dernier aspect n'a d'ailleurs pas pu être considéré dans notre analyse économique.

Cette recherche a été financée par le Consortium de recherche et innovations en bioprocédés industriels au Québec (CRIBIQ), Novalait et le Fond de recherche du Québec nature et technologies (FRQNT).

AFFICHE

Validation et développement de méthodes pour le suivi de la croissance pré-sevrage des génisses laitières

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Mots clés: Équation, Veaux laitiers, Poids, Mesures corporelles.

Résumé

La mesure du poids corporel (PC) est généralement considérée comme la référence afin d'évaluer la croissance optimale des veaux. La circonférence thoracique (CT) est souvent utilisée comme méthode indirecte pour estimer le poids. Les équations reliant les mesures de la CT avec le PC ont rarement été développées en utilisant des veaux avant le sevrage. Le but de cette étude était de valider l'utilisation de la mesure de la CT chez les veaux laitiers pendant la période précédant le sevrage afin d'estimer leur PC et de vérifier si d'autres mesures corporelles seraient également efficaces pour prédire le PC avant le sevrage. Une base de données a été développée avec le poids à la balance et différents paramètres liés à la taille du corps (circonférence thoracique, hauteur du garrot, hauteur aux hanches et largeur aux hanches) de 329 génisses laitières Holstein provenant de deux fermes laitières situées au Québec, Canada. Les mesures ont été prises trois fois par semaine pendant les trois premières semaines de vie et toutes les deux semaines jusqu'à la semaine suivant le sevrage à l'âge de 76 jours. Des analyses préliminaires avec des corrélations de Pearson ont été effectuées pour évaluer la relation entre le poids réel et les mesures corporelles. Des régressions simples ont ensuite été développées avec la procédure MIXED de SAS afin de prédire le PC en considérant le veau comme effet aléatoire. Une validation croisée avec randomisation en cinq groupes a été utilisée pour chaque variable indépendante afin d'évaluer les équations. L'équation de prédiction pour PC ayant le plus haut r (0,99) et le plus bas pourcentage de l'erreur quadratique moyenne prédite (RMSPE; 6,65) utilisait la CT : PC (kg) = 127,477 - 3,49 × CT (cm) + 0,03 × CT2. Des analyses subséquentes n'ont montré aucun biais moyen (0,163 kg; P = 0,41) ni biais linéaire (-0,002 kg, P = 0,33) pour l'équation proposée. En revanche, l'équation la plus souvent retenue en recherche, Heinrichs et al., (1992), présentait un biais moyen de 0,744 kg ($P < 0{,}001$) et un biais linéaire de -0,049 ($P < 0{,}001$). De plus, un léger biais a été observé pour l'équation la plus couramment utilisée au Québec qui était attribué à la variation aléatoire. La prédiction de gain moyen quotidien (GMQ) avait un plus haut r (0,83), le RMSPE le plus bas (9,38) avec l'équation la plus couramment utilisée au Québec et la majorité de l'erreur obtenue avec cette équation était associée à une variation aléatoire (> 80 %). L'équation proposée et l'équation de Heinrichs et al. (1992) ont obtenu 33,38 % et 28,06 % d'erreur associée au biais de prédiction, respectivement. Ainsi, ce projet valide l'utilisation de la CT pour estimer le poids des génisses avant le sevrage et démontre que l'équation actuellement utilisée au Québec est adéquate pour effectuer le suivi des veaux.

AFFICHE

Nutrition protéique : peut-on faire plus avec moins?

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Mise en contexte

Chez le bovin laitier, les recommandations actuelles concernant les besoins en protéines sont exprimées en termes de protéines métabolisables (PM), ce qui peut entraîner une suralimentation en certains acides aminés essentiels (AAE) et en acides aminés non essentiels. Une diminution des apports en PM, sans égard aux AAE, est toutefois typiquement associée à une baisse de la production laitière, probablement causée par un manque en certains AAE. La méthionine et la lysine sont souvent considérées comme étant les premiers AAE limitant la synthèse de protéines dans le lait lorsque les vaches sont nourries avec des rations typiquement nord-américaines. Récemment, l'histidine a aussi été identifiée comme potentiellement limitante dans les rations riches en fourrages ou encore à apport réduit en PM. L'objectif du présent projet était d'évaluer l'impact d'une variation de l'apport en énergie (94, 99 et 104 % des besoins) sur les performances des vaches laitières alimentées d'une ration riche en luzerne, ayant un apport réduit en PM (90 % des besoins), mais équilibrée pour les trois principaux AAE, et de mesurer aussi l'impact d'une réduction des apports en PM chez des vaches nourries à 99 % de leurs besoins énergétiques.

Résultats et applications pour l'industrie laitière

Dans cette expérience, la ration témoin comblait 100 % des besoins en PM, en AAE et en énergie. La prise alimentaire des vaches nourries de rations couvrant 90 % des besoins en PM n'était pas différente de celle des vaches recevant la ration témoin seulement lorsque l'apport en énergie était adéquat ou élevé (99 ou 104 % des besoins). Cependant, la production de lait corrigé pour l'énergie des vaches nourries d'une ration faible en PM était similaire à celle des vaches recevant la ration témoin (33,8 kg/jour) seulement lorsque la teneur en énergie était élevée (34,7 kg/jour), comparativement à des productions plus faibles de 29,0 et 30,5 kg/jour pour les rations couvrant 94 et 99 % des besoins en énergie. Par rapport à la ration témoin, une diminution des apports en PM et une augmentation des apports énergétiques a permis d'améliorer l'efficacité d'utilisation de la protéine par l'animal (azote protéique du lait/azote ingéré), passant de 25,6 % à 31,1 %, en plus d'améliorer l'efficacité alimentaire. Cette dernière ration a également permis de maintenir la production de gras et de protéines vraies du lait aux mêmes niveaux que ceux obtenus avec la ration témoin. Les trois rations faibles en PM ont permis de diminuer l'excrétion azotée ; celles ayant une teneur en énergie adéquate ou élevée ont de plus permis de réduire la teneur en urée du lait.

Retombées pour le secteur laitier

Il est donc possible de réduire les apports en PM sans avoir d'effet négatif sur la performance des bovins laitiers, à condition de combler leurs besoins en AAE et de revoir à la hausse les besoins énergétiques. De tels changements apportés à la ration permettraient de réduire les rejets azotés dans l'environnement, et ainsi de diminuer l'impact environnemental de la production laitière.

Partenaires financiers

Cette recherche a été financée par le Consortium de recherche et innovations en bioprocédés industriels au Québec (CRIBIQ), Novalait Inc., et le conseil de recherches en sciences naturelles et en génie du Canada (CRSNG), avec une participation financière du Centre de recherche en sciences animales de Deschambault (CRSAD). Le premier auteur a reçu des bourses de la commission canadienne du lait (CCL), en collaboration avec Novalait Inc., et du Fonds de recherche du Québec — Nature et technologies (FRQNT ; une session).

AFFICHE

La résistance aux antibiotiques: un regard dans nos fermes

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En médecine humaine aussi bien que vétérinaire, les antibiotiques sont utilisés afin de combattre les infections causées par les bactéries. La résistance aux antibiotiques est un phénomène durant lequel les bactéries développent des mécanismes de défense contre les antibiotiques. Ceux-ci deviennent alors inefficaces pour traiter des maladies. On sait maintenant que plus un animal reçoit d'antibiotiques, plus il a de chances d'être porteur de bactéries résistantes. Actuellement, aucun programme de surveillance n'évalue la situation de la résistance sur les fermes laitières du Québec, d'où l'importance de ce projet de recherche.

Nous avons donc testé plusieurs antibiotiques avec une bactérie (*E. coli*) présente dans le fumier des animaux, afin de voir si elle possédait des mécanismes de défense contre ces antibiotiques. La résistance la plus élevée était envers la tétracycline (trouvée dans certains produits injectables), les sulfonamides (dans certains produits oraux) et la streptomycine (dans un produit intra-mammaire). Les veaux avaient plus de bactéries résistantes que les vaches ou que la fosse à fumier. De plus, un type de mécanisme de résistance envers certains antibiotiques s'est révélé être d'intérêt pour la santé publique.

Dans l'immédiat, ces résultats mettent en lumière l'importance de la biosécurité (lavage des mains, nettoyage adéquat des parcs, etc.), car les animaux, en particulier les veaux, sont porteurs de nombreuses bactéries résistantes. La prochaine étape du projet sera de comparer l'utilisation des antibiotiques à la ferme avec la résistance observée. Le but est de favoriser une utilisation judicieuse des antibiotiques à moyen et long terme pour que les traitements utilisés restent le plus longtemps possible efficaces contre les infections.

Ces travaux ont été réalisés grâce à une aide financière du Programme Innov'action agroalimentaire, un programme issu de l'Accord Cultivons l'avenir 2 conclu entre le Ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Québec et Agriculture et Agroalimentaire Canada.

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AFFICHE

Quelle graminée fourragère cultiver avec la luzerne sur les fermes laitières québécoises dans un contexte de changements climatiques?

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[3] Ouranos, 550 rue Sherbrooke Ouest, Québec

Les changements climatiques auront un impact sur les rendements et la valeur nutritive des plantes fourragères. La fléole des prés, la graminée fourragère la plus cultivée au Québec en association avec la luzerne, n'échappera pas à cette situation. Afin de permettre aux producteurs laitiers de mieux s'adapter aux changements climatiques, cette étude propose d'évaluer comment les espèces de graminées fourragères actuellement recommandées en association binaire avec la luzerne performeront dans le futur.

Un ensemble de projections climatiques plausibles pour les périodes 2020-2049 (futur proche) et 2050-2079 (futur lointain) laissent entrevoir une saison de croissance plus longue ainsi que de plus grandes accumulations de degrés-jours et d'unités thermiques maïs (UTM), lesquelles prennent en considération la longueur de la saison de croissance et la température. À partir des informations climatiques et d'un modèle de simulation de la croissance des cultures, nous avons fait des projections pour le rendement et la valeur nutritive de la fléole de prés, la fétuque élevée, le brome des prés et la fétuque des prés en association avec la luzerne. Dans le Bas-Saint-Laurent, toutes les associations devraient profiter des changements climatiques avec une augmentation des rendements au cours du temps. Les associations avec la fétuque élevée, la fétuque des prés et le brome des prés devraient en bénéficier davantage que l'association avec la fléole des prés. C'est l'association avec la fétuque élevée qui en bénéficiera le plus. Les résultats de projections suggèrent aussi que la teneur en protéines brutes (PB) des associations devrait augmenter dans le temps, alors que la teneur de fibres insolubles au détergent neutre (NDF) devrait diminuer. Ceci peut s'expliquer par le fait que du scénario le moins extrême du futur proche en allant vers le scénario le plus extrême du futur lointain, la proportion de luzerne augmente dans le champ par rapport à la graminée. En Montérégie, les différentes associations fourragères devraient aussi bénéficier des changements climatiques, mais il n'y aurait pas de différences aussi importantes entre les différentes associations binaires. On devrait s'attendre à une hausse des rendements dans le futur proche, mais qui pourrait diminuer en importance dans le futur lointain, et ce, à cause des températures plus élevées que la température optimale en Montérégie.

Ces résultats de projections de rendement et de valeur nutritive ont ensuite été intégrés à un modèle de ferme globale. Pour le Bas-Saint-Laurent dans le futur proche et le futur lointain, les associations avec la fétuque élevée ou le brome des prés sont celles qui entraîneraient les bénéfices nets les plus élevés à l'échelle de la ferme. Ces résultats s'expliquent surtout par la possibilité de vente des récoltes de grandes cultures. En effet, les rendements élevés de l'association avec la fétuque élevée et une conjugaison entre le rendement et la bonne teneur en PB de celle avec le brome des prés devraient permettre de cultiver les fourrages sur une moins grande superficie. À l'inverse, la fétuque des prés semble moins bien adaptée aux conditions futures plausibles examinées dans cette étude. En Montérégie, comme la différence entre les rendements est moins marquée, toutes les associations devraient permettre un bénéfice net similaire. Notre analyse, qui considérait seulement l'impact des changements climatiques sur les cultures, montre que les entreprises laitières pourraient s'attendre à une augmentation de leurs bénéfices nets. En fait, ces résultats laissent présager que les entreprises laitières pourront vendre plus de cultures à revenus et acheter moins de concentrés. L'adaptation aux changements climatiques par la modification du choix de la graminée fourragère à cultiver en association avec la luzerne est déjà amorcée. Projeter l'évolution future des associations de luzerne avec une espèce de graminée actuellement recommandée permet aux producteurs laitiers québécois de faire un choix plus éclairé.

Ce projet fut mené par le Département des sciences animales de l'Université Laval avec Ouranos comme principal partenaire scientifique et financier. Le Fonds vert a aussi financé ce projet dans le cadre du Plan d'action 2013-2020 sur les changements climatiques du gouvernement du Québec.

La première fois et la dernière? L'impact du premier cas de mammite ou de boiterie sur la rentabilité des vaches laitières primipares

Maria A. Puerto*[1], Roger I. Cue[1], Daniel Warner[1,2], Elsa Vasseur[1]

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La mammite et la boiterie, des maladies répandues chez les troupeaux laitiers québécois, sont reconnues pour augmenter le taux de réforme involontaire dans les élevages. Pour étudier l'impact de ces maladies sur la rentabilité des vaches en première lactation, une analyse rétrospective a été réalisée à l'aide d'un modèle mixte (où l'effet troupeau a été considéré aléatoire) sur une base de données collectées par Lactanet sur la période s'échelonnant entre 2003 et 2014. L'objectif était de comparer, grâce aux 13 516 observations récoltées sur 103 troupeaux, le profit brut généré chez les vaches dont le premier cas de mammite (n=1770) ou de boiterie (n=1063) a été observé pendant la période de transition ou le début de la lactation, à celui généré par les vaches pour lesquelles aucun cas de mammite ou de boiterie n'ont été relevés. Comparativement à ces dernières, les vaches chez lesquelles un premier cas de mammite a été observé durant la période de transition et durant le début de la lactation ont généré une perte de 424$ et 637$ sur 305 jours, respectivement. Pour les vaches ayant eu un premier cas de boiterie durant ces mêmes périodes, la diminution du profit brut généré était de 449$ et 466$, comparativement aux vaches saines.

Ces données montrent que l'impact des épisodes de mammite et boiterie dépasse la durée de la période de maladie elle-même, et que ces problèmes de santé ont des répercussions à long terme sur le profit généré au cours de la lactation. Ces informations pourraient aider les producteurs à prendre des décisions de réforme plus éclairées, afin de maximiser la rentabilité des troupeaux laitiers québécois.

Merci à tous les partenaires financiers pour leur soutien: bourse étudiante via le programme FONCER du CRSNG, ainsi que le CRSNG, Novalait, les Producteurs Laitiers du Canada et Lactanet, via la Chaire de Recherche Industrielle sur la Vie durable des bovins laitiers détenue par Elsa Vasseur, PhD.

AFFICHE

Comment rendre la base de stalle plus confortable

Sarah McPherson et Elsa Vasseur

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Pour l'industrie laitière canadienne, il importe de proposer des solutions concrètes et efficaces pour améliorer le confort des vaches. L'un des aspects du logement qui contribuent le plus au confort est la stalle, qui est à la fois défini par sa taille (combinaison de la largeur et de l'espace longitudinal) et par ses composantes matérielles (base de la stalle, type de litière et profondeur de litière). Ce projet de recherche visait à évaluer dans un contexte de stabulation entravée l'impact combiné de trois aspects de la stalle qui contribuent au confort des vaches laitières : la longueur de la stalle, la hauteur du muret, et la profondeur de litière.

Pour ce projet de recherche, deux rangées de 12 stalles ont été modifiées. L'une des deux rangées comportait des stalles à la base plus courte (178 cm ou 70 po), la longueur commune dans les fermes québécoises) alors que l'autre comportait des stalles à la base plus longue (188 cm ou 44 po). Au sein de ces rangées ont été appliqués au hasard deux hauteurs de muret : un muret haut (20 cm, la limite supérieure de la recommandation actuelle) et un muret court (5 cm). Une couche de 7,6 cm (ou 3 po) de litière de paille a été maintenue dans les stalles à l'aide d'un garde-litière installé à l'arrière de chacune des stalles. Vingt-quatre vaches ont été divisées en 6 blocs en fonction du nombre de parités (2,7 ± 0,32) et de jours en lait (115 ± 13,2 JEL), puis réparties entre quatre groupes comptant une vache de chaque bloc. Deux de ces groupes ont été assignés à chacune des deux rangées pour deux périodes consécutives de 6 semaines de traitement et 1 semaine d'adaptation, une période par traitement (hauteur de muret). Les blessures corporelles ont été relevées sur un total de 17 endroits sur chacune des vaches, et analysées en fonction de leur évolution par rapport à leur état au début de la période de traitement. Les comportements de repos ont été enregistrés en continu à l'aide d'accéléromètres attachés aux pattes arrières.

Toutes les parties du corps qui étaient blessées au début de l'étude ont démontré des signes de guérison au cours des 14 semaines de l'étude. Pour les blessures aux jarrets, une amélioration a été relevée au cours des semaines 1 à 6, peu importe la longueur et la hauteur du muret ($P \leq 0{,}001$ pour le jarret; $P \leq 0{,}01$ pour la pointe du jarret). Le temps de repos (14,1 vs. 13,3 h/j; $P < 0{,}05$) et la durée des épisodes de repos (74,1 vs. 52,9 min/épisode; $P < 0{,}05$) étaient plus longs chez les vaches installées dans les stalles plus longues, comparativement à celles dans les stalles courtes. La hauteur du muret n'a pas eu d'impact sur les blessures ni le temps de repos. Les temps de repos observés étaient similaires à ceux observés chez les vaches installées sur litière profonde compostée, indiquant que l'ajout de plus de litière a rendu les stalles plus confortables, avec un effet plus marqué en combinaison avec des stalles plus longues. Les données sur les blessures confirment que l'augmentation de la quantité de litière a un effet protecteur, permettant même la guérison dans un court laps de temps. L'utilisation d'un garde-litière pour maintenir une plus grande profondeur de litière semble être une solution raisonnable et applicable pour les fermes en stabulation entravée. Une telle mesure pourrait être utile pour les producteurs souhaitant augmenter le confort et le temps de repos de leurs vaches, tout en les préservant mieux des blessures corporelles.

Merci aux partenaires financiers ayant soutenu ce projet : le CRSNG, Novalait, les Producteurs Laitiers du Canada, ainsi que Lactanet, en tant que partenaires de la chaire de recherche industrielle sur la vie durable des bovins laitiers détenue par Elsa Vasseur, Ph.D.

AFFICHE

Performances reproductives et laitières des vaches Holstein ayant des niveaux élevés de BHB dans le lait en début de lactation

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Département des sciences animales, Université Laval, Québec, QC
Centre for Genetic Improvements of Livestock, University of Guelph, Guelph, ON

La santé et les performances optimales des vaches en lactation dépendent d'une période de transition réussie. Les désordres métaboliques, dont l'hypercétonémie en début lactation, ont une prévalence relativement élevée au Québec, soit 22%. L'hypercétonémie est caractérisée par des niveaux élevés de BHB (beta-hydroxybutyrate) dans le sang, mais de récentes avancées ont permis de mesurer de manière fiable le BHB dans le lait par spectrométrie infrarouge. Selon des analyses conduites chez Valacta entre 2011 et 2017 sur 318 543 vaches Holstein provenant de 3551 troupeaux du Québec, 9% des vaches ont été considérées positives (≥0.20 mmol BHB par litre) et 12% des vaches ont été considérées suspectes (≥0.15) au jour de test. Les taux élevés de BHB étaient plus fréquents chez les vaches qui produisaient des volumes de lait plus importants tout au long d'une lactation de 305 jours. Néanmoins, l'hypercétonémie amène un taux de réforme plus élevé et une réduction des performances de reproduction chez les vaches : plus de jours ouverts, un intervalle première saillie-conception plus élevé, un nombre plus élevé de saillies par conception, et une diminution du pourcentage cumulatif de vaches gestantes au fil des jours en lactation. Tous ces effets nuisent à la longévité des vaches dans les troupeaux et illustrent la nécessité d'une bonne transition et d'un monitoring rigoureux de son troupeau.

Le profil d'acides gras du lait de réservoir: Seuils et indicateurs dans notre contexte québécois

Daniel Warner, René Lacroix, Daniel M Lefebvre et Débora E. Santschi

Lactanet, Sainte-Anne-de-Bellevue, QC

Le profil d'acides gras (AG) du lait de réservoir suscite un intérêt accru comme outil de gestion du troupeau. Certains AG du lait sont synthétisés dans la glande mammaire et sont liés à un rumen en santé (AG de novo), tandis qu'autres AG proviennent de l'alimentation ou de la mobilisation de réserves corporelles (AG préformés). Afin d'établir des seuils pour les troupeaux au Québec, une analyse comparative (étude « benchmark ») a été conduite sur une base de données sur 3462 troupeaux du Québec avec de plus de 300 000 échantillons de lait analysés par spectroscopie infrarouge à Lactanet depuis avril 2019. Bien que les AG de novo sont bien corrélés avec le taux de gras et protéine (R^2 = 0.66), les profils du lait varient considérablement au Québec selon la race (plus élevés pour les troupeaux Jersey), système de production (plus bas pour les troupeaux bio) et système de traite (plus bas pour les troupeaux avec traite robotisée). Les AG de novo étaient plus élevés pour les 10% de troupeaux les plus performants (+0.53 g/100 g d'AG totaux en moyenne) par rapport aux 10% les moins performants. Ces seuils seront utiles aux producteurs pour comparer les performances de leur troupeau avec des troupeaux de conditions similaires. Des travaux de recherche futurs porteront sur les associations entre les profils d'AG du réservoir et les bonnes pratiques à la ferme pour établir des recommandations pour les producteurs selon leurs pratiques d'alimentation et gestion, de même que le potentiel génétique.

Symposium sur les bovins laitiers

Le mardi 29 octobre 2019

Centrexpo Cogeco Drummondville

Conférences

CRAAQ
Comité bovins laitiers

Symposium sur les bovins laitiers

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Les acides gras dans l'alimentation de la vache – Quoi? Pourquoi? Comment?

Rachel Gervais, Ph.D., agr.,
professeure au Département des sciences animales, Université Laval

<u>Collaborateurs</u>
[1]P.Y. Chouinard et [2]D.E. Rico

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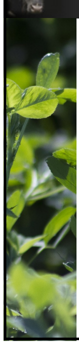
Plan de la présentation

- Les acides gras dans l'alimentation
- L'impact des suppléments d'acides gras sur:
  - prise alimentaire
  - digestibilité de la ration
  - production laitière
  - composition du lait
- Les acides gras et la santé de la vache

Les acides gras de la diète - fourrages



Ensilage de légumineuses

	% matière sèche
Matière organique	90
Protéine brute	20
ADF	37
NDF	46
Gras	3,1

NRC, 2001

Les analyses courantes permettent de déterminer l'extractif à l'éther ou le % de gras des ingrédients. Toutefois, pour certains de ces ingrédients, notamment les fourrages, une grande proportion de cet extractif est constituée de composés sans valeur nutritive. La détermination du profil en acides gras nous permet de contourner ce problème et nous donne une idée beaucoup plus précise de la teneur en énergie de la ration.

Extractif à l'éther (Gras)

	% EE
Acides gras	43
Galactose	8
Glycerol	9
Chlorophylle	4
Cires	17
Autres	19

Palmquist et Jenkins, 1980

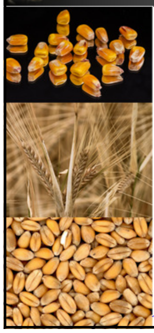
Profil en acides gras

	% acides gras
16:0	24
18:0	4
18:1	7
18:2	21
18:3	41

Boufaïed *et al.*, 2003

Les fourrages de légumineuses et de graminées sont particulièrement riches en acide linolénique (18:3), un acide gras oméga-3. Ils contiennent aussi une bonne quantité d'acide linoléique (18:2).

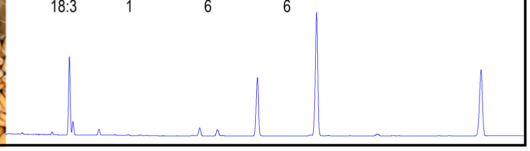
Les acides gras de la diète - grains



INRA, 2002

	Maïs	Orge	Blé
16:0	11	22	18
18:0	2	2	1
18:1	27	12	15
18:2	57	55	56
18:3	1	6	6

Les lipides de la plupart des ingrédients inclus dans les rations pour vaches laitières sont constitués de 5 acides gras principaux (voir tableau). Pour la grande majorité des céréales, l'acide gras qui prédomine est l'acide linoléique (18:2). C'est aussi vrai pour le maïs grain.

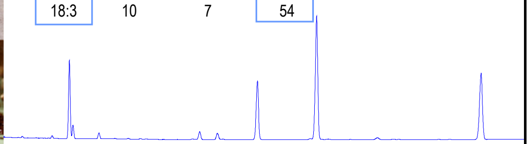


Les acides gras de la diète - oléagineux

INRA, 2002

	Canola	Soya	Lin
16:0	4	11	6
18:0	2	4	3
18:1	58	22	19
18:2	21	53	15
18:3	10	7	54

Le profil en acides gras des graines oléagineuses varie considérablement selon l'espèce concernée. Ainsi, la graine de canola est riche en acide oléique (18:1), la graine de soya en acide linoléique (18:2) et la graine de lin en acide linolénique (18:3).



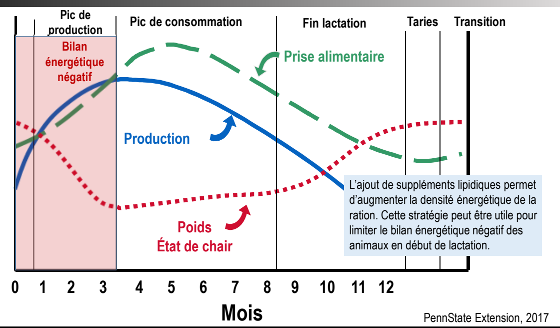
Ratio fourrages : concentrés

	70:30	30:70
	-------% matière sèche-------	
Ensilage d'herbe	60	25
Foin graminées	10	5
Orge roulée	9	29
Maïs cassé	9	29
Tourteau de soya	6	7
Fin gluten de maïs	3	3
Vitamines et minéraux	2	2
	-------% acides gras-------	
16:0	18	17
18:0	2	2
18:1	11	17
18:2	36	46
18:3	32	18

Saliba *et al.*, 2014

Puisque les profils en acides gras des fourrages et des concentrés sont très différents, des modifications du ratio fourrages:concentrés auront un impact certain sur la quantité et la nature des acides gras offerts aux animaux. Ces modifications peuvent influencer considérablement la synthèse des composantes du lait.

Suppléments lipidiques



Suppléments lipidiques inertes

La densité énergétique de la plupart des suppléments lipidiques disponibles sur le marché est au moins 2,5× plus grande que celle des grains.

Maïs	Orge	Huile végétale	Sels de Ca d'huile de palme	Suif hydrolysé et hydrogéné
		Mcal NE_L/kg matière sèche		
1,91	1,86	5,65	5,02	6,89

> 2,5 ×

Suppléments lipidiques inertes

	Suif	Suif hydrolysé et hydrogéné
	------% des acides gras-------	
16:0	26	28
18:0	19	57
18:1	44	5,2
18:2	3,7	0,5
18:3	0,5	n.d.

Chouinard *et al.*, 2008 — Dallaire *et al.*, 2014

Un supplément fréquemment utilisé est le suif hydrolysé et hydrogéné. Celui-ci présente une concentration élevée en acide stéarique (18:0) et en acide palmitique (16:0)

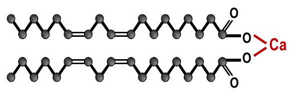
Suppléments lipidiques inertes

Plusieurs autres suppléments lipidiques disponibles sur le marché sont issus de l'huile de palme.

Huile de palme

	%
16:0	43,5
18:1	36,6
18:2	9,3

Les sels de Calcium d'huile de palme sont inertes dans le rumen et contiennent des proportions équivalentes d'acide palmitique (16:0) et d'acide oléique (18:1).



RG27

Suppléments lipidiques inertes

Les suppléments enrichis en acide palmitique (16:0) sont à base de super stéarine, un sous-produit de la transformation de l'huile de palme.

Huile de palme

	%
16:0	43,5
18:1	36,6
18:2	9,3

Oléine — Stéarine

Super oléine

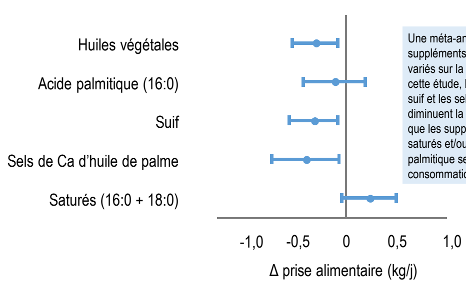
	%
16:0	35,4
18:1	45,1
18:2	13,4

Super stéarine

	%
16:0	85,6
18:1	7,1
18:2	1,5

Prise alimentaire

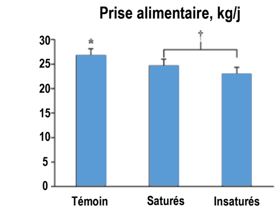
Weld et Armentano, 2017

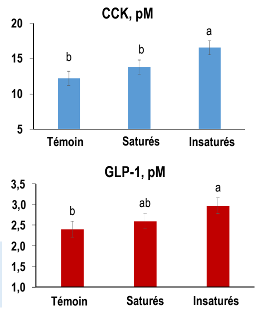


Une méta-analyse a révélé que les suppléments lipidiques ont des effets variés sur la prise alimentaire. Selon cette étude, les huiles végétales, le suif et les sels de Ca d'huile de palme diminuent la prise alimentaire, alors que les suppléments d'acides gras saturés et/ou enrichis en acide palmitique semblent ne pas affecter la consommation des animaux.

Prise alimentaire

Bradford *et al.* 2008

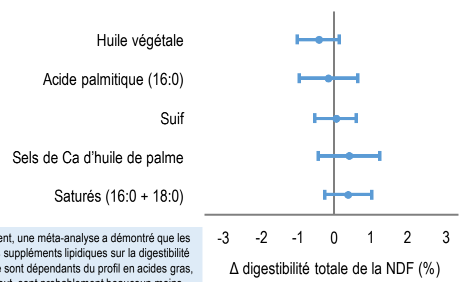




Les effets des suppléments lipidiques sur la prise alimentaire sont dépendants du profil en acides gras. Les acides gras insaturés, lorsqu'ils atteignent l'intestin, provoquent l'envoi de signaux de satiété à l'animal (e.g. CCK et GLP-1).

Digestibilité de la fibre

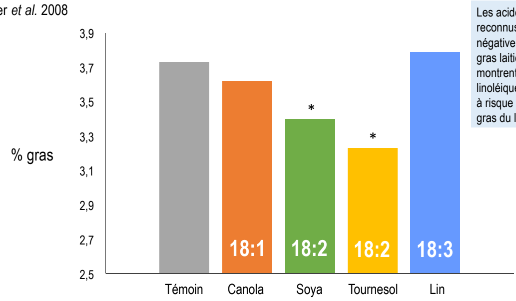
Weld et Armentano, 2017



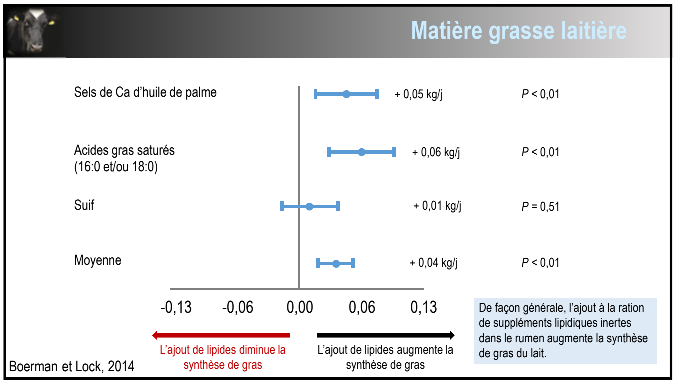
Récemment, une méta-analyse a démontré que les effets des suppléments lipidiques sur la digestibilité de la fibre sont dépendants du profil en acides gras, mais surtout, sont probablement beaucoup moins significatifs que ce qui est généralement rapporté.

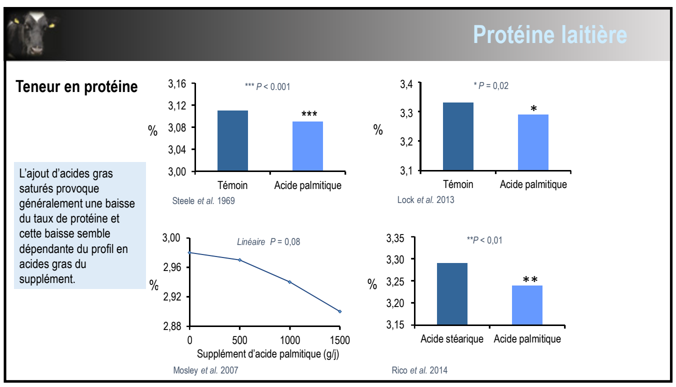
Matière grasse laitière

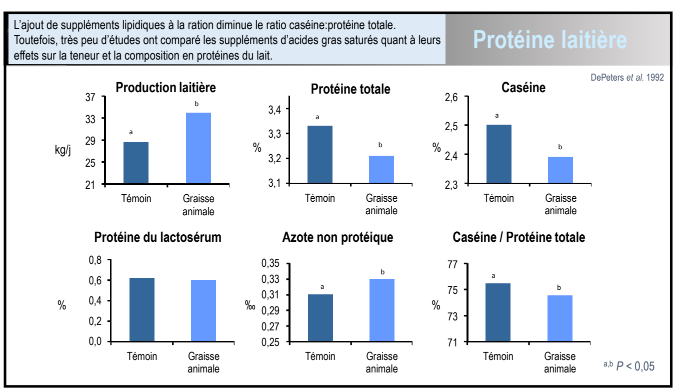
Glasser *et al.* 2008



Les acides gras insaturés sont reconnus pour affecter négativement la synthèse du gras laitier. Les études montrent que c'est l'acide linoléique (18:2) qui est le plus à risque de diminuer le taux de gras du lait.


Matière grasse laitière
Sels de Ca d'huile de palme
+ 0,05 kg/j
P < 0,01
Acides gras saturés
(16:0 et/ou 18:0)
+ 0,06 kg/j
P < 0,01
Suif
+ 0,01 kg/j
P = 0,51
Moyenne
+ 0,04 kg/j
P < 0,01
-0,13
-0,06
0,00
0,06
0,13
L'ajout de lipides diminue la synthèse de gras
L'ajout de lipides augmente la synthèse de gras
De façon générale, l'ajout à la ration de suppléments lipidiques inertes dans le rumen augmente la synthèse de gras du lait.
Boerman et Lock, 2014


Protéine laitière
Teneur en protéine
L'ajout d'acides gras saturés provoque généralement une baisse du taux de protéine et cette baisse semble dépendante du profil en acides gras du supplément.
*** P < 0.001
%
3,16
3,12
3,08
3,04
3,00
***
Témoin
Acide palmitique
Steele et al. 1969
* P = 0,02
%
3,4
3,3
3,2
3,1
*
Témoin
Acide palmitique
Lock et al. 2013
Linéaire P = 0,08
%
3,00
2,96
2,92
2,88
0
500
1000
1500
Supplément d'acide palmitique (g/j)
Mosley et al. 2007
**P < 0,01
%
3,35
3,30
3,25
3,20
3,15
**
Acide stéarique
Acide palmitique
Rico et al. 2014


L'ajout de suppléments lipidiques à la ration diminue le ratio caséine:protéine totale. Toutefois, très peu d'études ont comparé les suppléments d'acides gras saturés quant à leurs effets sur la teneur et la composition en protéines du lait.
Protéine laitière
DePeters et al. 1992
Production laitière
kg/j
37
33
29
25
21
Protéine totale
%
3,4
3,3
3,2
3,1
Caséine
%
2,6
2,5
2,4
2,3
Protéine du lactosérum
%
0,8
0,6
0,4
0,2
0,0
Azote non protéique
‰
0,35
0,33
0,31
0,29
0,27
0,25
Caséine / Protéine totale
%
77
75
73
71
a
b
Témoin
Graisse animale
a,b P < 0,05

Les acides gras et la santé de la vache

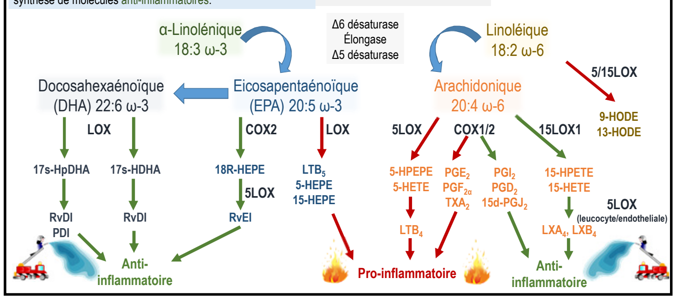
- Les acides gras oméga-3 et l'inflammation en période de transition
- Les suppléments lipidiques et la répartition des nutriments
- Les suppléments lipidiques et la reproduction

Les acides gras oméga-3 et inflammation

Les acides gras essentiels (18:2 et 18:3) sont impliqués dans le fonctionnement du système immunitaire des animaux. Les acides gras oméga-6 sont précurseurs de molécules pro-inflammatoires alors que les acides gras oméga-3 mènent à la synthèse de molécules anti-inflammatoires.

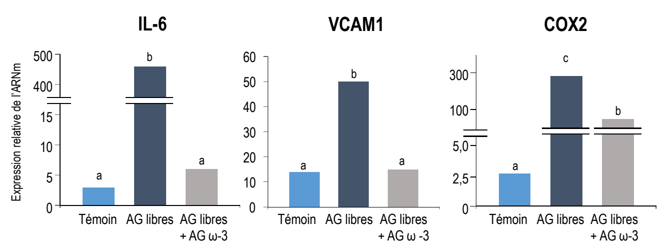
des eicosanoïdes

Adapté de Sordillo *et al.* 2009



Acides gras oméga-3 et oxylipides

Des études ont montré qu'il est possible, en ajoutant des acides gras oméga-3, de limiter la synthèse de molécules responsables des réactions inflammatoires chez la vache en transition.

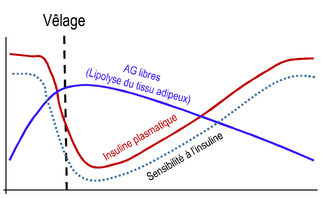


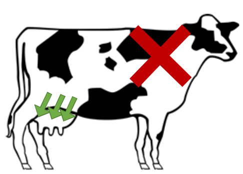
Contreras *et al.* 2012

Acides gras oméga-3 et inflammation

Bien que les recherches récentes nous permettent d'espérer mieux contrôler l'inflammation chez les animaux en transition, il reste encore beaucoup de travaux à réaliser afin de connaître précisément les interventions nutritionnelles qui sont les plus aptes à aider les vaches laitières dans cette période critique.

Suppléments lipidiques et répartition des nutriments

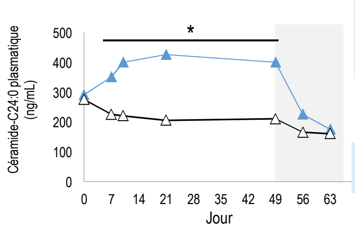




Au début de la lactation, des signaux hormonaux dirigent l'énergie disponible vers la glande mammaire aux détriments des autres tissus de l'animal.

Suppléments lipidiques et répartition des nutriments

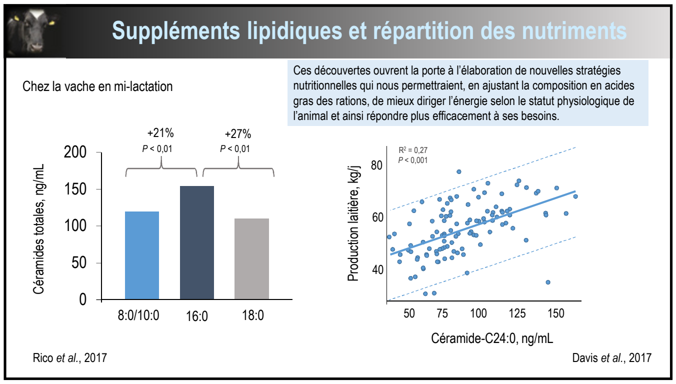
Acide palmitique (16:0) → ↗ Céramides plasmatiques

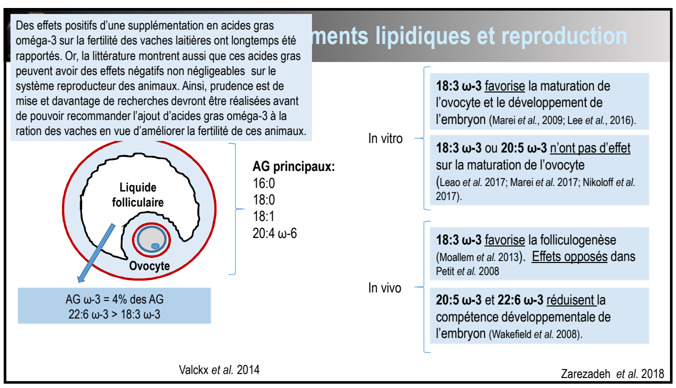


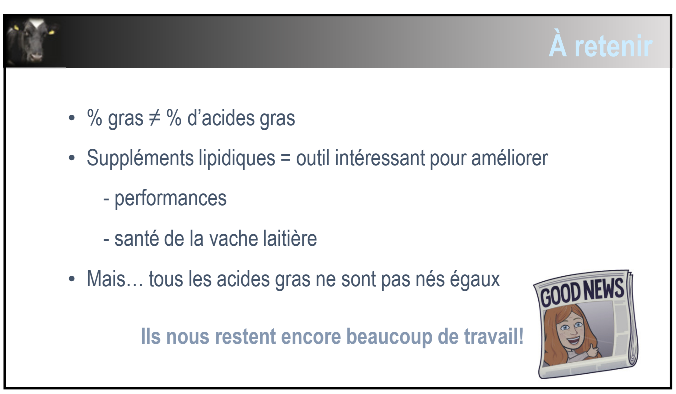
De récentes découvertes ont montré que l'ajout de suppléments lipidiques pouvait influencer les signaux qui régulent la distribution des nutriments aux différents tissus de l'animal.

Les céramides sont des lipides reconnus pour leur rôle dans la résistance à l'insuline.

Rico *et al.* 2016


Suppléments lipidiques et répartition des nutriments
Chez la vache en mi-lactation
Ces découvertes ouvrent la porte à l'élaboration de nouvelles stratégies nutritionnelles qui nous permettraient, en ajustant la composition en acides gras des rations, de mieux diriger l'énergie selon le statut physiologique de l'animal et ainsi répondre plus efficacement à ses besoins.
+21%
P < 0,01
+27%
P < 0,01
Céramides totales, ng/mL
200
150
100
50
0
8:0/10:0
16:0
18:0
R² = 0,27
P < 0,001
Production laitière, kg/j
80
60
40
50
75
100
125
150
Céramide-C24:0, ng/mL
Rico et al., 2017
Davis et al., 2017


ments lipidiques et reproduction
Des effets positifs d'une supplémentation en acides gras oméga-3 sur la fertilité des vaches laitières ont longtemps été rapportés. Or, la littérature montrent aussi que ces acides gras peuvent avoir des effets négatifs non négligeables sur le système reproducteur des animaux. Ainsi, prudence est de mise et davantage de recherches devront être réalisées avant de pouvoir recommander l'ajout d'acides gras oméga-3 à la ration des vaches en vue d'améliorer la fertilité de ces animaux.
Liquide folliculaire
Ovocyte
AG principaux:
16:0
18:0
18:1
20:4 ω-6
AG ω-3 = 4% des AG
22:6 ω-3 > 18:3 ω-3
In vitro
In vivo
18:3 ω-3 favorise la maturation de l'ovocyte et le développement de l'embryon (Marei et al., 2009; Lee et al., 2016).
18:3 ω-3 ou 20:5 ω-3 n'ont pas d'effet sur la maturation de l'ovocyte (Leao et al. 2017; Marei et al. 2017; Nikoloff et al. 2017).
18:3 ω-3 favorise la folliculogenèse (Moallem et al. 2013). Effets opposés dans Petit et al. 2008
20:5 ω-3 et 22:6 ω-3 réduisent la compétence développementale de l'embryon (Wakefield et al. 2008).
Valckx et al. 2014
Zarezadeh et al. 2018


À retenir
• % gras ≠ % d'acides gras
• Suppléments lipidiques = outil intéressant pour améliorer
- performances
- santé de la vache laitière
• Mais… tous les acides gras ne sont pas nés égaux
Ils nous restent encore beaucoup de travail!
GOOD NEWS


Merci

Symposium sur les bovins laitiers

Le mardi 29 octobre 2019
Centrexpo Cogeco, Drummondville

Stress thermique durant le tarissement : Effets sur la vache et la génisse

Geoffrey E Dahl, Ph.D., professeure et titulaire de la chaire Harriet B. Weeks,
Department of Animal Sciences, University of Florida

Stress thermique durant le tarissement : Effets sur la vache et la génisse

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Institut de l'alimentation et des sciences agricoles
gdahl@ufl.edu
Symposium sur les bovins laitiers
29 octobre 2019

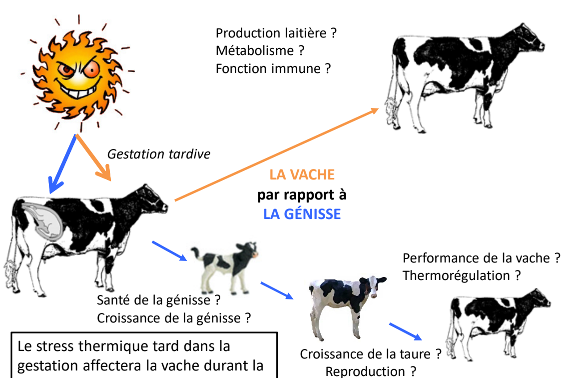
UF UNIVERSITY of FLORIDA

Stress thermique durant la lactation

- Diminue la consommation volontaire de matière sèche (CVMS)
- Réduit la production laitière
- Des études récentes suggèrent des effets métaboliques additionnels au-delà de la CVMS
- Le rétablissement dépend de la durée

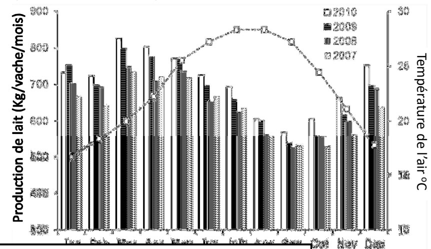
Qu'en est-il des vaches taries ?

Le stress thermique réduit la prise alimentaire et la production laitière chez les vaches laitières. Toutefois, la vache gaspille de l'énergie supplémentaire pour éliminer le surplus de chaleur. Donc, elle est encore plus inefficiente que ne le suggère la CVMS moindre.



Le stress thermique tard dans la gestation affectera la vache durant la prochaine lactation, de même que la génisse en croissance dans l'utérus.

Les effets du stress thermique sur la production persistent.



Production moyenne/vache/mois en Floride sur 4 ans ; tracé par rapport à la moyenne des températures élevées. Confirme un pic de lactation saisonnier en mars/avril et un creux en sept./oct. La température culmine en juin/juil. On note un décalage (2 mois) par rapport au creux de la production laitière. Donc, il ne s'agit pas seulement d'un effet de lactation.

Tao & Dahl, *J. Dairy Sci.* 96:4079-4093

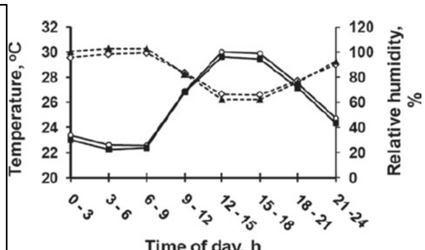
Gainesville, Floride, É.-U.

- **Stab. libre, litières de sable**
- **Ventilateurs au-dessus des stalles**
- **Système d'aspersion au-dessus de la mangeoire**
- **Ventilateurs démarrent à 70° F (21,1°C)**
- **Gicleurs fonctionnent 1,5 min/5 min à 72 F**

Installation où s'effectuent nos études — étable typique en Floride. Litière en sable, stabulation libre 4 rangées. Résultats pertinents pour l'industrie.

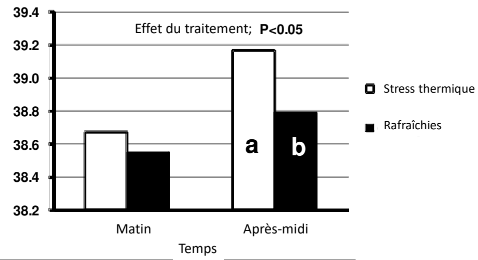
Plan de l'étude : Charge thermique des vaches taries

Relation typique entre la température de l'air et l'humidité relative dans nos étables durant une étude ; l'indice température humidité (ITH) est toujours élevé. La température culmine en après-midi, alors que l'humidité plafonne tôt le matin. On doit rafraîchir la vache pour diminuer le stress thermique.



Do Amaral et coll., *J. Dairy Sci.* 94:86-96

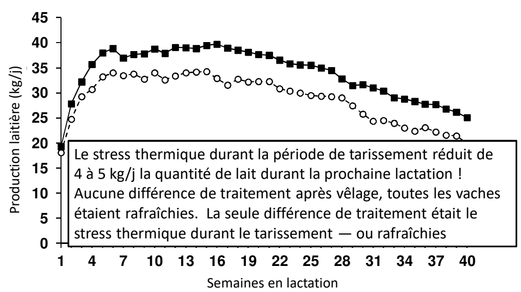
Le stress thermique augmente la température rectale moyenne



En l'absence d'un système pour les rafraîchir, même à l'ombre, les vaches subissent un stress thermique. Habituellement, cela se traduit par une augmentation de ~0,4ºC de la température rectale. Le taux de la respiration augmente aussi, au-dessus de 60 bpm.

Do Amaral et coll., *J. Dairy Sci.* 94:86-96

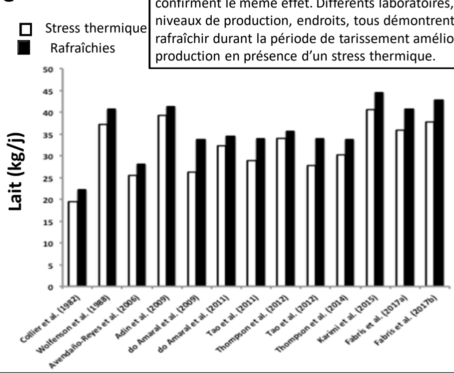
Rafraîchir les vaches taries accroît la production laitière

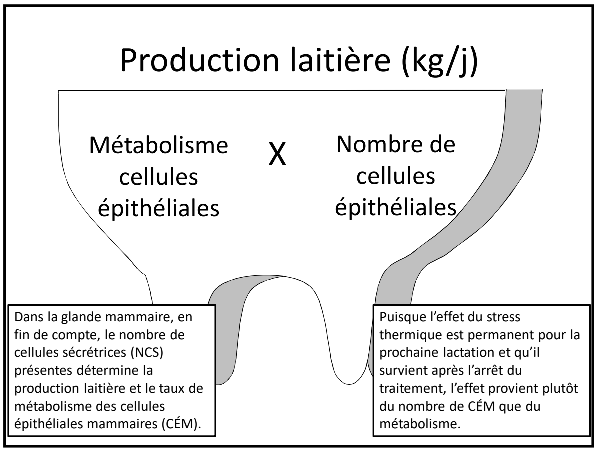


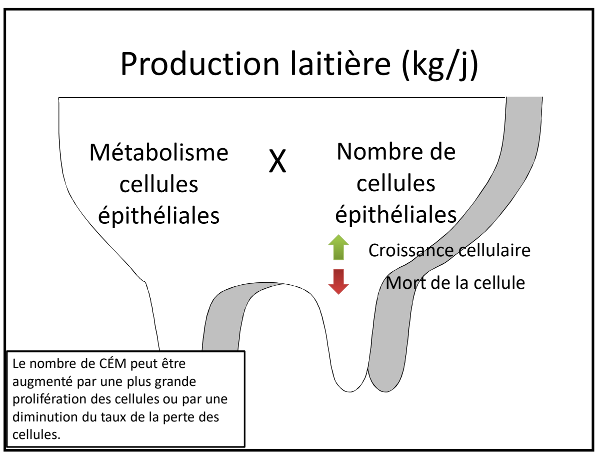
Tao et coll., *J. Dairy Sci.* 94:5976–5986

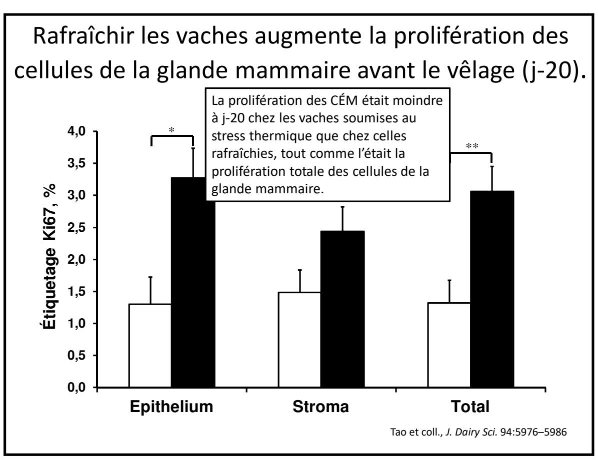
Rafraîchir les vaches taries accroît la production laitière

Pas une seule étude, plusieurs études publiées confirment le même effet. Différents laboratoires, niveaux de production, endroits, tous démontrent que rafraîchir durant la période de tarissement améliore la production en présence d'un stress thermique.

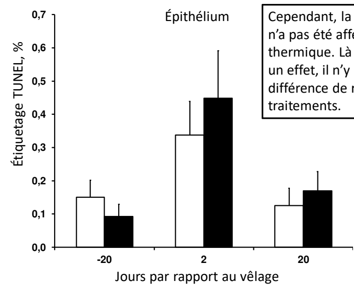



Production laitière (kg/j)
Métabolisme cellules épithéliales
X
Nombre de cellules épithéliales
Dans la glande mammaire, en fin de compte, le nombre de cellules sécrétrices (NCS) présentes détermine la production laitière et le taux de métabolisme des cellules épithéliales mammaires (CÉM).
Puisque l'effet du stress thermique est permanent pour la prochaine lactation et qu'il survient après l'arrêt du traitement, l'effet provient plutôt du nombre de CÉM que du métabolisme.


Production laitière (kg/j)
Métabolisme cellules épithéliales
X
Nombre de cellules épithéliales
Croissance cellulaire
Mort de la cellule
Le nombre de CÉM peut être augmenté par une plus grande prolifération des cellules ou par une diminution du taux de la perte des cellules.


Rafraîchir les vaches augmente la prolifération des cellules de la glande mammaire avant le vêlage (j-20).
La prolifération des CÉM était moindre à j-20 chez les vaches soumises au stress thermique que chez celles rafraîchies, tout comme l'était la prolifération totale des cellules de la glande mammaire.
Étiquetage Ki67, %
4,0
3,5
3,0
2,5
2,0
1,5
1,0
0,5
0,0
*
**
Epithelium
Stroma
Total
Tao et coll., J. Dairy Sci. 94:5976–5986

Stress thermique durant le tarissement — Pas d'effet sur l'apostose des CÉM



Cependant, la perte de cellules n'a pas été affectée par le stress thermique. Là où le temps a eu un effet, il n'y a pas eu de différence de réponse entre les traitements.

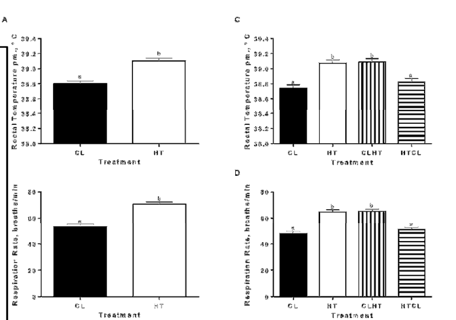
Tao et coll., *J. Dairy Sci.* 94:5976–5986

Durée de la période où rafraîchir

- Dois-je rafraîchir les vaches durant toute la période de tarissement ?
- Puis-je les rafraîchir seulement en fin de période ?

Le stress thermique augmente la température rectale et le taux de respiration

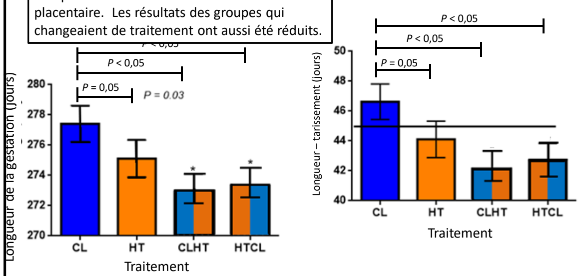
Durant la première moitié de la période de tarissement, le stress thermique augmente la température rectale et le taux de respiration. Après le changement de traitement, les vaches ont réagi comme prévu au passage du stress thermique ou à l'environnement rafraîchi.



Fabris et coll., *J. Dairy Sci.*, 102:5647-5656

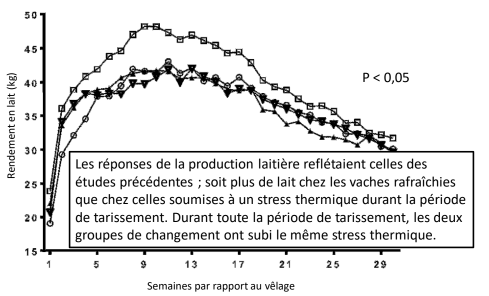
En tout temps, le stress thermique réduit la durée de la gestation et la longueur de la période de tarissement

Tant la longueur de la période de gestation que celle du tarissement étaient plus courtes chez les vaches soumises au stress thermique. Cela indique une réduction de la fonction placentaire. Les résultats des groupes qui changeaient de traitement ont aussi été réduits.



Fabris et coll., *J. Dairy Sci.,* 102:5647-5656

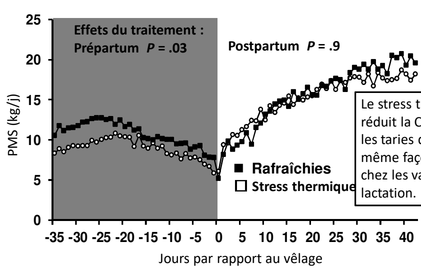
En tout temps durant la période de tarissement, le stress thermique diminue la production laitière



Les réponses de la production laitière reflétaient celles des études précédentes ; soit plus de lait chez les vaches rafraîchies que chez celles soumises à un stress thermique durant la période de tarissement. Durant toute la période de tarissement, les deux groupes de changement ont subi le même stress thermique.

Fabris et coll., *J. Dairy Sci.,* 102:5647-5656

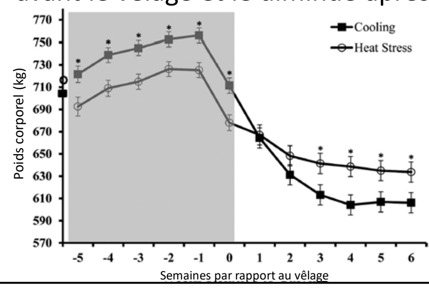
Le stress thermique réduit la CVMS avant vêlage mais pas après le vêlage



Le stress thermique réduit la CVMS chez les taries de la même façon que chez les vaches en lactation.

Tao et coll., *J. Dairy Sci.* 94:5976-5986

Rafraîchir les vaches taries augmente le poids avant le vêlage et le diminue après



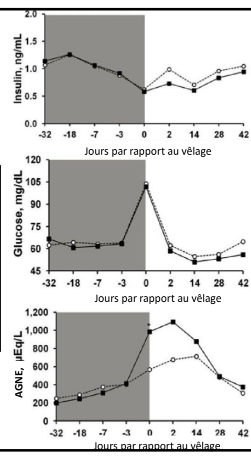
Les vaches taries soumises au stress thermique ne gagnent pas de poids durant le tarissement et n'en perdent pas autant en début lactation ce qui est constant avec les différences de production laitière.

Thompson et coll., *J. Dairy Sci.* 97:7426-7436

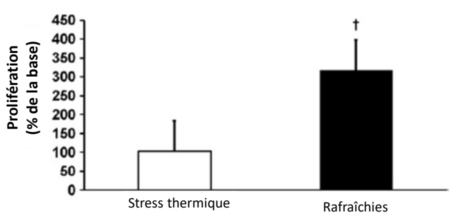
Effet sur le profil métabolique de rafraîchir les vaches taries

Aucune différence observée concernant l'insuline, le glucose ou les acides gras non estérifiés (AGNE) durant le tarissement lorsque les vaches sont soumises à un stress thermique. Postpartum, les vaches rafraîchies durant le tarissement avaient plus d'acide gras libre, ce qui correspond une production laitière plus élevée.

Tao et coll., *J. Dairy Sci.* 95:5035-5046



Rafraîchir les vaches taries favorise la prolifération des lymphocytes

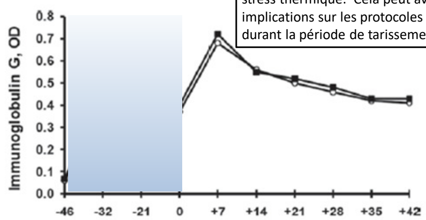


Les vaches soumises au stress thermique affichent des signes d'un statut immunitaire réduit par rapport aux vaches rafraîchies ; soit une réduction directe de la prolifération des cellules blanches.

Do Amaral et coll., *Domest. Anim. Endo.* 38:38-45

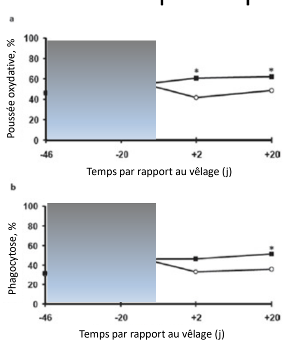
Rafraîchir les vaches taries
Effets sur l'immunité acquise

La production d'anticorps en réponse à un stress immunitaire est aussi réduite par le stress thermique. Cela peut avoir des implications sur les protocoles de vaccination durant la période de tarissement.



Do Amaral et coll., *J. Dairy Sci.* 94:86-96

Rafraîchir les vaches taries augmente l'action des neutrophiles postpartum



Le système immunitaire inné n'est pas directement affecté par le stress thermique durant la période de tarissement. Toutefois, après le vêlage, les vaches exposées au stress thermique avant le vêlage affichent une activité réduite des neutrophiles par rapport à celles qui ont été rafraîchies.

Do Amaral et coll., *J. Dairy Sci.* 94:86-96

Le tarissement durant les mois FRAIS améliore la performance

Tableau 1. Production et cas de mammite, de problèmes respiratoires et digestifs, rétention de placenta et métrites chez les vaches taries durant les mois chauds (juin, juillet, août ou froids (déc., janv., fév.) durant les premiers 80 jours de la lactation suivante

	Taries durant les mois chauds (Juin, Juil, Août), n=1 569				Taries durant les mois froids (Déc., Janv., Fév.), n=1 044				
Élément	**Valeur**	**Maladie[1]**	**n**	**%**	**Valeur**	**Maladie[1]**	**n**	**%**	***P*-valeur**
Production en lait (kg)	10,351 ± 59.8				10,902 ± 73.3				0.01
Mammite		0	1,286	82.0		0	950	91.0	0.01
		1	283	18.0		1	94	9.0	
Digestif		0	1,516	96.6		0	973	93.2	0.01
		1	53	3.4		1	71	6.8	
Respiratoire		0	1,346	85.8		0	942	90.2	0.01
		1	223	14.2		1	102	9.8	
Rétentions du placenta		0	1,500	95.6		0	1,013	97.0	0.06
		1	69	4.4		1	31	3.0	
Métrites		0	1,500	95.6		0	1,007	96.4	0.35
		1	67	4.2		1	38	3.5	

[1]Maladie : 0 = vaches sans maladie; [1]Maladie : vaches malades

Les vaches taries en été ont produit moins et ont connu plus de cas de mammite, plus de problèmes respiratoires et plus de rétention placentaire par rapport aux vaches taries durant l'hiver.

Thompson & Dahl, *Prof. Anim. Sci.* 28:628-631

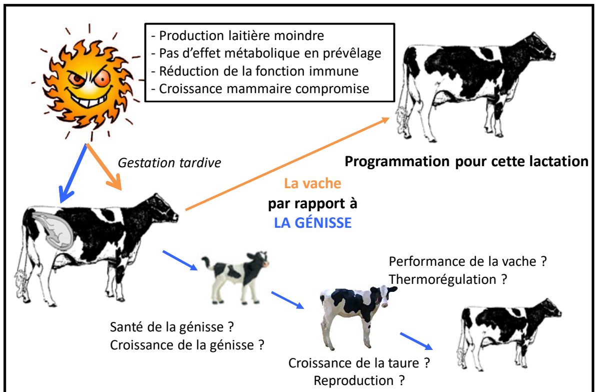
Le tarissement durant les mois FRAIS améliore la performance reproductive

Tableau 3. Production de lait et performance reproductive des vaches taries durant les mois chauds (juin, juillet, août) ou durant les mois froids (déc., janv., fév.) durant les 150 premiers jours en lait de la lactation subséquente sur une ferme commerciale en Floride.

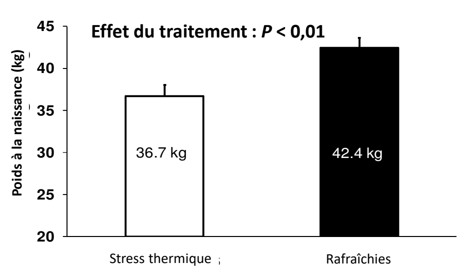
Élément	Taries durant les mois chauds (juin, juillet, août)	Taries durant les mois froids (déc., janv., fév.)	*P*-valeur
Production de lait (kg)	10,547 ± 67.0	11,005 ± 83.38	0.01
Nombre de saillies (n)	1,048	676	0.03
Moyenne (j)	1.59 ± 0.02	1.51 ± 0.03	
JEL à saillie (n)	1,047	676	0.01
Moyenne (j)	97.0 ± 0.74	91.8 ± 0.92	
JEL à gravide (n)	1,051	679	0.01
Moyenne (j)	131.1 ± 0.85	125.9 ± 1.06	

Les vaches taries en été démontraient une performance reproductive moindre par rapport aux vaches taries durant l'hiver, malgré une production laitière moindre et le fait d'avoir été saillies durant les mois plus frais.

Thompson & Dahl, *Prof. Anim. Sci.* 28:628-631



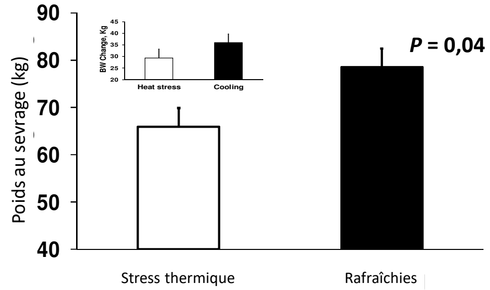
Rafraîchir améliore le poids de la génisse à la naissance



Les génisses nées de vaches exposées au stress thermique ont un poids moindre à la naissance due à la gestation plus courte et à la fonction placentaire réduite. Cela confirme les études précédentes.

Tao et coll., *J. Dairy Sci.* 95:7128-7136

Poids au sevrage

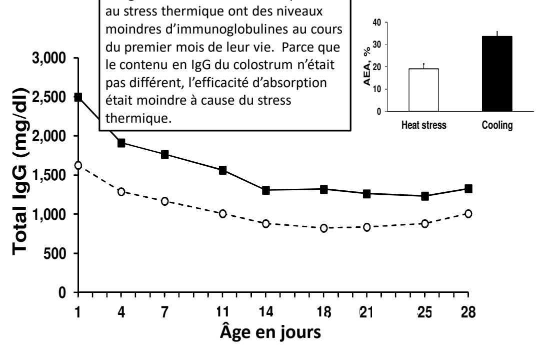


Les génisses nées de vaches exposées au stress thermique ont un poids moindre au sevrage. Cela indique que les limites à la croissance persistent après la naissance.

Tao et coll., *J. Dairy Sci.* 95:7128-7136

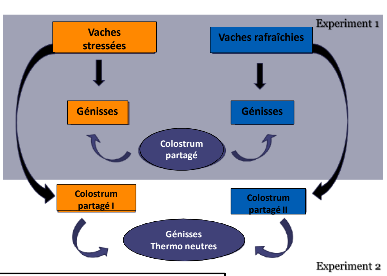
Rafraîchir améliore les IgG totales et l'EAA

Les génisses nées de vaches exposées au stress thermique ont des niveaux moindres d'immunoglobulines au cours du premier mois de leur vie. Parce que le contenu en IgG du colostrum n'était pas différent, l'efficacité d'absorption était moindre à cause du stress thermique.



Tao et coll., *J. Dairy Sci.* 95:7128-7136

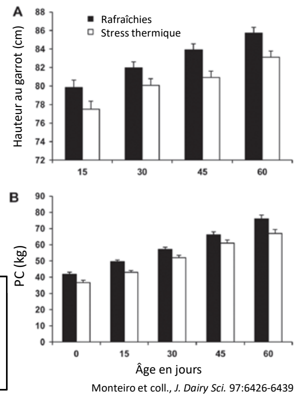
Rafraîchir — influence l'absorption, pourquoi ? Effet sur le colostrum ou sur la génisse ?



Tester pour voir si l'effet du stress thermique sur la génisse est direct ou indirect par le colostrum.

Monteiro et coll., *J. Dairy Sci.* 97:6426-6439

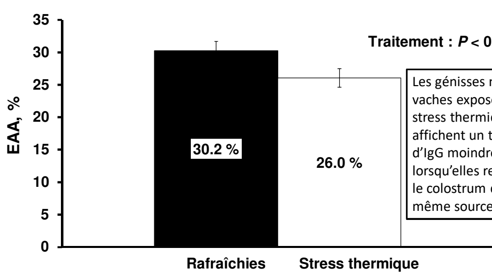
Expérience 1 — Le stress thermique intra-utérin pour ~6 semaines réduit le poids et la hauteur au sevrage



Monteiro et coll., *J. Dairy Sci.* 97:6426-6439

Les génisses nées de vaches exposées au stress thermique ont poids moindre à la naissance et au sevrage. Elles sont moins hautes au sevrage. L'impact sur la stature suggère qu'il y a un effet sur la croissance musculaire maigre.

Rafraîchir accroît l'EAA* des IgG



Les génisses nées de vaches exposées au stress thermique affichent un transfert d'IgG moindre, même lorsqu'elles reçoivent le colostrum d'une même source.

* EAA = [Sérum [IgG] (g/L) * poids à la naissance (kg) * 0,091 / IgG alimenté (g)] x 100

Expérience 2 — **Pas d'effet** du colostrum venant de vaches rafraîchies ou exposées au stress thermique sur la performance des génisses

Performance de croissance des génisses nées de vaches sous conditions thermo neutres durant le tarissement, génisses alimentées de colostrum congelé provenant de vaches exposées soit au stress thermique ou rafraîchies durant le tarissement.

Paramètre	Stress thermique MMC ± ÉT	Rafraîchies MMC ± ÉT	*P*-valeur
Poids à la naissance (kg)	38.8 ± 1.4	39.2 ± 1.5	0.8
Poids au sevrage (kg)	68.4 ± 2.5	64.8 ± 2.6	0.4
Gain PC avant sevrage (kg)	29.6 ± 2.3	25.6 ± 2.4	0.3
Gain moyen quotidien (kg)	0.49 ± 0.7	0.43 ± 0.8	0.2
Hauteur au garrot (cm)	84.3 ± 0.8	83.0 ± 0.9	0.4
Augmentation hauteur avant sevrage (cm)	7.8 ± 1.1	6.2 ± 1.0	0.3

[1]Le poids au sevrage et la hauteur au sevrage ont été mesurés à 60 jours d'âge.

[2]Le gain en poids avant sevrage et l'augmentation de la hauteur ont été calculés individuellement en soustrayant des données à 60 jours d'âge celles à la naissances.

Monteiro et coll., *J. Dairy Sci.* 97:6426-6439

La consommation du colostrum venant d'une vache exposée au stress thermique n'a pas eu d'effet sur la croissance ou sur le transfert d'IgG chez la génisse n'ayant pas subi de stress thermique intra-utérin.

Résumé sur le stress thermique — effets à court terme sur les génisses

- Rafraîchir accroît le poids à la naissance et au sevrage
- Le stress thermique intra-utérin réduit l'efficacité apparente d'absorption des IgG, mais n'a pas d'effet sur la qualité du colostrum
- Le stress thermique intra-utérin affecte le métabolisme des glucides, fait corroboré par un plus grand dépôt de gras.

J. Dairy Sci. 92:5988–5999
doi:10.3168/jds.2009-2343
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Heat-stress abatement during the dry period: Does cooling improve transition into lactation?

B. C. do Amaral, E. E. Connor, S. Tao, J. Hayen, J. Bubolz, and G. E. Dahl

J. Dairy Sci. 94:86–96
doi:10.3168/jds.2009-3004
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Heat stress abatement during the dry period influences metabolic gene expression and improves immune status in the transition period of dairy cows

B. C. do Amaral, E. E. Connor, S. Tao, M. J. Hayen, J. W. Bubolz, and G. E. Dahl

J. Dairy Sci. 94:5976–5986
doi:10.3168/jds.2011-4329
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Effect of heat stress during the dry period on mammary gland development

S. Tao, J. W. Bubolz, B. C. do Amaral, I. M. Thompson, M. J. Hayen, S. E. Johnson, and G. E. Dahl

J. Dairy Sci. 95:5035–5046
http://dx.doi.org/10.3168/jds.2012-5405
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Effect of cooling heat-stressed dairy cows during the dry period on insulin response

S. Tao, I. M. Thompson, A. P. A. Monteiro, M. J. Hayen, L. J. Young, and G. E. Dahl

J. Dairy Sci. 97:7426–7436
http://dx.doi.org/10.3168/jds.2013-7621
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Effect of cooling during the dry period on immune response after *Streptococcus uberis* intramammary infection challenge of dairy cows

I. M. T. Thompson, S. Tao, A. P. A. Monteiro, K. C. Jeong, and G. E. Dahl

Analyse rétrospective des données de 5 études sur des génisses, études tenues entre 2007 et 2011

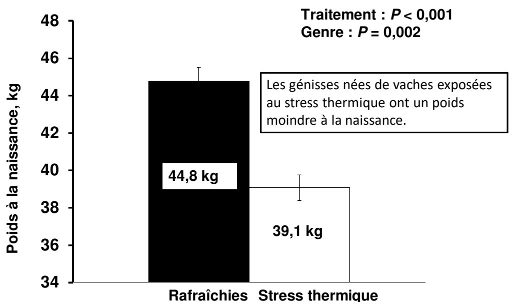
Monteiro et coll. J. Dairy Sci. 99:8443-8450.

On cherchait à connaître les effets à long terme du stress thermique intra-utérin sur la croissance, la survie et la productivité. Nous avons dû combiner les données provenant d'une série d'études effectuées sous les mêmes conditions au cours de 5 ans.

Expériences sur le stress thermique de 2007 à 2011

	Taureaux	Génisses	**Total**
Rafraîchir	31	41	72
Stress thermique	30	44	74
Total	61	85	147

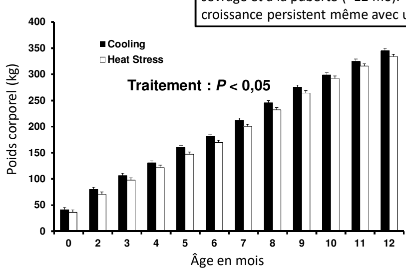
Poids à la naissance



Monteiro et coll. , *J. Dairy Sci.* 99:8443-8450.

Le stress thermique intra-utérin diminue le poids de la génisse jusqu'à la puberté

Les génisses nées de vaches exposées au stress thermique ont un poids moindre à la naissance, au sevrage et à la puberté (~12 mo). Les réductions de croissance persistent même avec une gestion commune.



Monteiro et coll. , *J. Dairy Sci.* 99:8443-8450.

Le stress thermique intra-utérin diminue la survie du veau

Tableau 1. Effet sur la survie de la génisse de l'exposition maternelle au stress thermique (ST) ou rafraîchie (RA) tard en gestation

Paramètre	RA				ST				P
	IA	FIV[1]	Total	%[2]	IA	FIV[1]	Total	%[2]	Trait.[3]
Veaux, n	30	1	31	---	28	2	30	---	---
Génisses, n	29	12	41	---	29	15	44	---	---
Morts nés[4]	0	0	0	0.0	2	1	3	4.1	0.25
Mortalité des veaux à 4 mois	1	0	1	3.2	3	0	3	10.0	0.35
Taures quittant le troupeau avant la puberté	1	4	5	12.2	3	7	10	22.7	0.26
Dû à maladie, malformation ou croissante lente	1	0	1	2.4	3	5	8	18.2	0.03
Taures quittant le troupeau après la puberté, avant la première lactation	1	0	1	2.4	3	0	3	6.8	0.62
Taures complétant la première lactation	27	8	35	85.4	22	7	29	65.9	0.05

[1]FIV = fertilisation in vitro
[2]Pourcentage des animaux (IA + FIV) affectés par rapport au total des animaux (mâles et femelles) dans chaque traitement
[3]Traitement
[4]Mort né (veaux et génisses inclus)

Les génisses nées de vaches exposées au stress thermique quittent le troupeau à un taux plus élevé avant la puberté, ce qui confirme leur statut immunitaire moindre. De plus, moins de ces génisses atteignent la première lactation.

Monteiro et coll. , *J. Dairy Sci.* 99:8443-8450.

Le stress thermique intra-utérin diminue les performances reproductives

Tableau 2. Effet du stress thermique (ST) maternel ou rafraîchies (RA) tard en gestation sur la performance en reproduction avant la première lactation des taures nées de vaches ST ou RA.

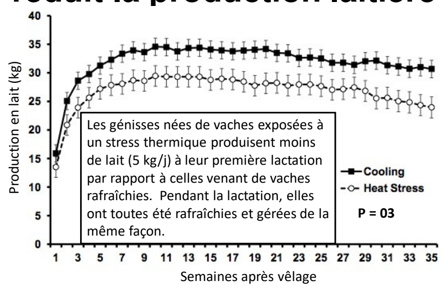
Paramètre	RA	ST	ET	*P*
N	36	32	---	---
Âge à première saillie (IA)	13.6	13.8	0.2	0.32
Saillies par conception j[1] 30	2.0	2.5	0.2	0.05
Âge à conception j[1] 30, mois	16.1	16.9	0.3	0.07
Services par conception j[1] 50	2.3	2.6	0.2	0.32
Âge au vêlage, mois	24.8	25.0	0.4	0.72

[1]Jours après insémination

Les génisses nées de vaches exposées au stress thermique tendent à avoir des performances reproductives moindres, bien que le nombre de sujets de l'analyse est petit.

Monteiro et coll. , *J. Dairy Sci*. 99:8443-8450.

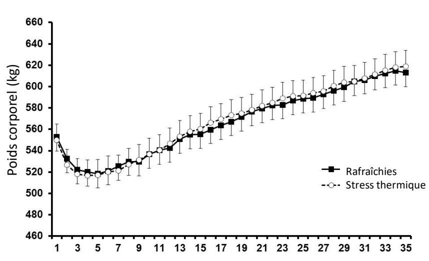
Le stress thermique intra-utérin réduit la production laitière



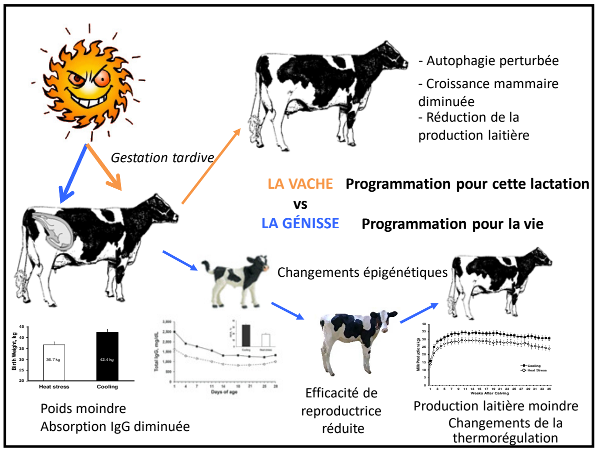
Les génisses nées de vaches exposées à un stress thermique produisent moins de lait (5 kg/j) à leur première lactation par rapport à celles venant de vaches rafraîchies. Pendant la lactation, elles ont toutes été rafraîchies et gérées de la même façon.

Monteiro et coll. , *J. Dairy Sci*. 99:8443-8450.

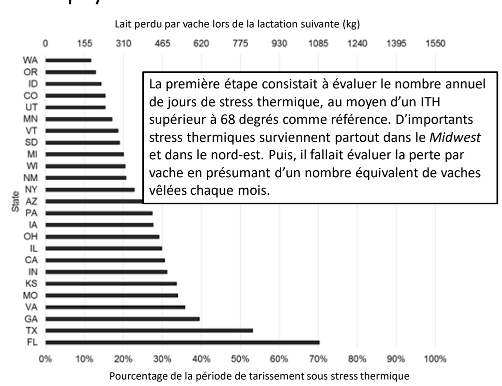
Le stress thermique intra-utérin n'affecte pas le poids à l'âge adulte



Monteiro et coll. , *J. Dairy Sci*. 99:8443-8450.

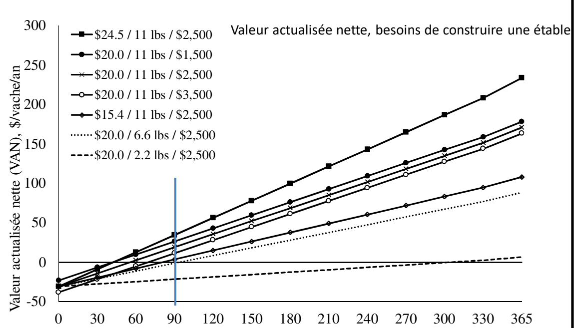


Est-ce payant de rafraîchir les vaches taries ?



Ferreira et coll. , *J. Dairy Sci.* 99:9931-9941.

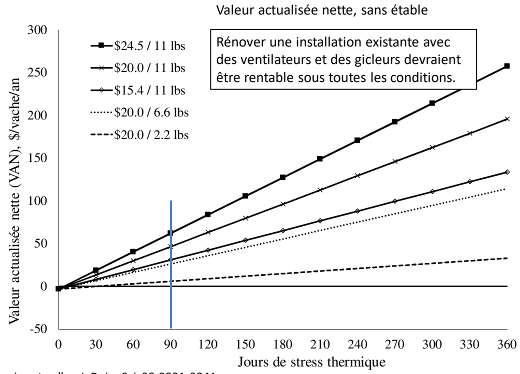
Est-ce payant de rafraîchir les vaches taries ?



Ferreira et coll. , *J. Dairy Sci.* 99:9931-9941.

L'analyse de la VAN indique que aussi peu que 60 jours de stress thermique annuellement suffisent pour justifier de rafraîchir les vaches taries dans une nouvelle installation.

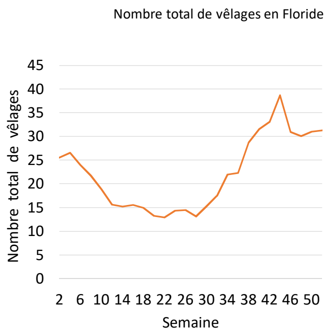
Est-ce payant de rafraîchir les vaches taries ?



Rénover une installation existante avec des ventilateurs et des gicleurs devraient être rentable sous toutes les conditions.

Ferreira et coll. , *J. Dairy Sci.* 99:9931-9941.

Est-ce payant de rafraîchir les vaches taries ? Saisonnalité



Toutefois, notre analyse suppose un nombre égal de vêlages chaque mois, ce qui n'est pas exact. Plus de vaches vêlent à l'automne. Donc, plus de vaches du troupeau subissent potentiellement le stress thermique durant le tarissement. En fait, il s'agit d'évaluations très conservatrices.

Symposium sur les bovins laitiers

Le mardi 29 octobre 2019
Centrexpo Cogeco, Drummondville

Le métabolisme des vaches est-il programmé épigénétiquement?

Marc-André Sirard, D.M.V., Ph.D., professeur titulaire de la Chaire de recherche du Canada en génomique de la reproduction

CRAAQ
Comité bovins laitiers

Le métabolisme des vaches est-il programmé épigénétiquement?

Marc-André Sirard, DMV, PhD.

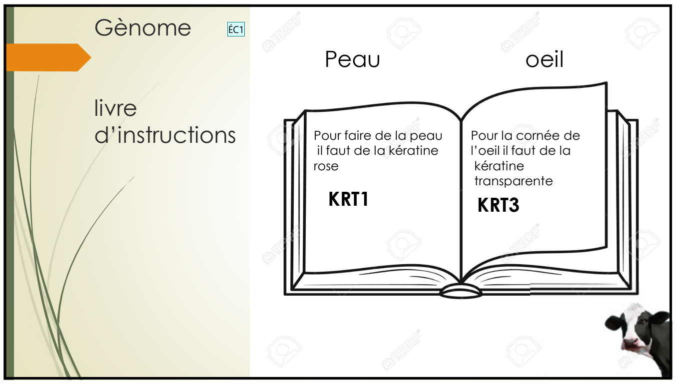
Chaire de Recherche du Canada en Génomique de la Reproduction
Centre de Recherche en Reproduction, Développement et Santé Inter-générationnelle (CRDSI)
Département des Sciences Animales ,Université Laval

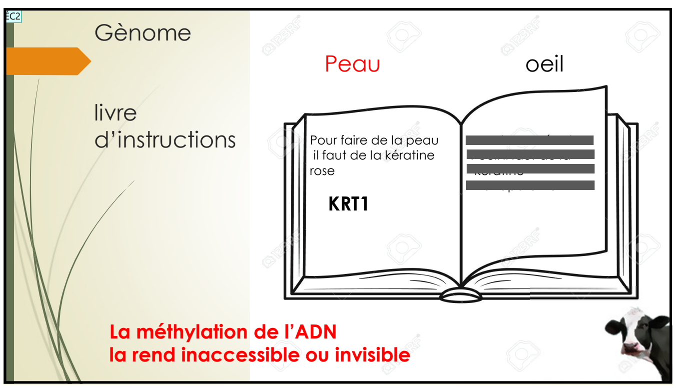
plan

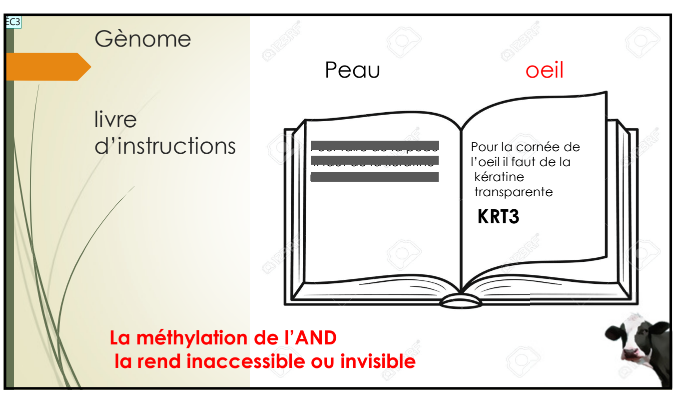
- L'épigénétique: c'est quoi?
- La programmation métabolique
- La vache postpartum et sa génisse
- Les considérations économiques
- Message a retenir

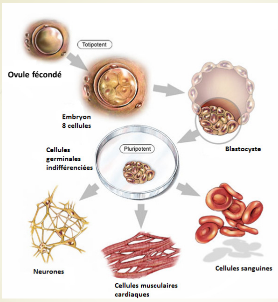
Qu'est-ce que l'épigénétique ?

- « épi » = autours des gènes (génétique)
- Altération de l'expression des gènes sans modifications de la séquence d'acides nucléiques des gènes.
- Permanente (méthylation) ou temporaire (histones)
- 3 méthodes principales
  - peinturer l'ADN (permanente = méthylation)
  - ou envelopper l'ADN (temporaire = histones)
  - attaquer le messager (ARN) avec des micro ARN


Gènome
livre d'instructions
Peau
oeil
Pour faire de la peau il faut de la kératine rose
KRT1
Pour la cornée de l'oeil il faut de la kératine transparente
KRT3


Gènome
livre d'instructions
Peau
oeil
Pour faire de la peau il faut de la kératine rose
KRT1
La méthylation de l'ADN
la rend inaccessible ou invisible


Gènome
livre d'instructions
Peau
oeil
Pour la cornée de l'oeil il faut de la kératine transparente
KRT3
La méthylation de l'AND
la rend inaccessible ou invisible



Toutes nos cellules ont le même génome

Mais chaque tissus fonctionne différemment

Nécessité d'une reprogrammation de l'embryon!

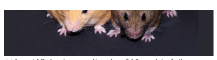
Preeti Gokal Rochar, 2004

ÉPIGÉNÉTIQUE

Des animaux génétiquement identiques

L'épigénétique suggère que nos modes de vie, notre nourriture, notre histoire influencent le phénotype, notre apparence, notre santé et également l'héritage biologique que nous léguons. L'environnement agit sur notre ADN qui est transcrit en ARN messager qui lui servira à la production de protéines. Ce sont les différentes protéines qui composent une cellule qui effectuent les différentes fonctions de cette cellules et qui par le fait même définissent la dite cellule.

Génétiquement identiques, nourries différemment La reine reçoit la gelée royale.



Mère déficiente en vitamine B12, acide folique, bétaïne et choline.
Influence l'épigénétique du gène Agouti

DOHaD. (Developmental Origin of health and disease)

- Hypothèse de Barker est basé sur la première analyse statistique réalisée par David Barker (1938 - 2013) sur des données de faible poids à la naissance recueillies au début des années 1900 dans le sud-est de l'Angleterre.
- Suivi de personnes nées durant la famine de 1944-45
  - Les enfants nés suite à un famine au début de la gestation ont démontré des risques accrus de maladies cardiovasculaire
- Depuis les expérimentations animales en condition contrôlés démontrent que le métabolisme est programmé dans les ovule et spermatozoïdes avant même la fécondation.
  - Par exemple les souriceaux nés de pères ou de mères obèses seront obèses même avec une diète normale.

Données bovines

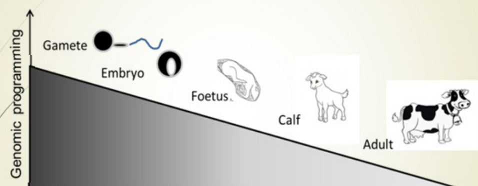
- Étude de Evans (Dublin)
- La restriction alimentaire avant et au début de la gestation (100 jours) a entrainé une progéniture avec une réserve ovarienne diminuée (évaluée par une **réduction du nombre de follicules antraux, et augmentation de la pression artérielle par rapport aux témoins**.
- Cette étude établit un lien entre la dénutrition maternelle transitoire et l'augmentation de la production d'androgènes maternels avec une réserve ovarienne diminuée ainsi qu'un potentiel de fertilité sous-optimal.

Et nous, en Amérique on recommande l'insémination à un moment où la vache perd du poids…..

Mossa F, Carter F, Walsh SW, Kenny DA, Smith GW, Ireland JL, Hildebrandt TB, Lonergan P, Ireland JJ, Evans AC. Maternal undernutrition in cows impairs ovarian and cardiovascular systems in their offspring. Biol Reprod. 2013 Apr 11;88(4):92.

11

Plus l'environnement intervient tôt, plus la programmation est importante



Plasticité diminue avec l'âge

La programmation épigénétique est plus importante et a un effet plus grand au début de la

12

La vache postpartum et sa génisse

- Chute des paramètres de reproduction
  - ↑ intervalle **vêlage-première ovulation**
  - ↓ réduction de la **durée de l'œstrus**
  - ↓ du taux de **succès à la 1ère insémination**
  - ↑**nombre de saillies** par vache

(Butler, 1998; Lucy, 2001; Lopez-Gatius, 2003; Pryce, 2004; Dillon, 2006; Macdonald et al., 2008; Walsh et al., 2011).

La vache postpartum et sa génisse

13

Les facteurs en cause

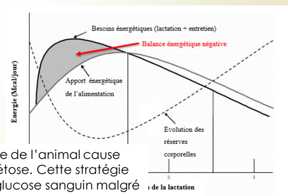
- Intensification de la sélection génétique
- Pathologie utérine (métrite, contamination)
- Condition de chair
- Balance énergétique négative (BEN)
- Désordres métaboliques

Plusieurs auteurs partagent l'idée que la chute des performances reproductives observée au sein des troupeaux laitiers est un problème multifactoriel et complexe (Butler, 1998; Veerkamp et al., 2003) et leurs interactions rendent difficile la détermination de la raison exacte du déclin de la fertilité au sein des troupeaux .

Qu'est-ce que la balance énergétique négative?

14

- Besoins en énergie > énergie consommée
- Plusieurs facteurs peuvent en influencer son importance
  - Génétique
  - Cote de chair
  - Production laitière
  - Consommation de MS
  - Alimentation
- Production de corps cétoniques
  - Bêta-hydroxybutyrate (BHB)



L'accumulation de ces corps cétoniques dans l'organisme de l'animal cause une pathologie métabolique nommée acétonémie ou cétose. Cette stratégie adaptative de la vache permet de maintenir le taux de glucose sanguin malgré une demande accrue du métabolisme en début lactation

Pourquoi s'y intéresser?

15

- Effets sur le cycle œstral
  - ↓ la fréquence des pulses de la LH
  - ↓ de la sensibilité des ovaires à la LH
  - ↓ la production d'estrogène et d'IGF-I
  - ↓ concentration d'œstradiol
  - ↓ de la concentration en insuline
- Effets sur le rétablissement de l'utérus

Chute des performances de reproduction

Les changements métaboliques subits par l'animal suite à la parturition entraînent des effets sur le retour ainsi que la normalité du cycle œstral, diminuant alors le succès de l'insémination subséquente (Wathes et al., 2007c). En inséminant à 60 jours, les follicules qui doivent ovuler au moment de la conception subissent leurs premiers stades de développement au moment où la balance énergétique négative est la plus importante (Wathes et al., 2003; Taylor et al., 2004).

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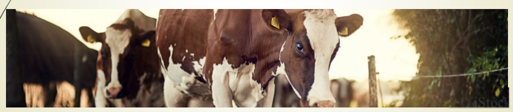
Hypothèse

La balance énergétique négative peut affecter la **qualité embryonnaire** et possiblement expliquer la faible **fertilité** entre les jours 40 et 90 post-partum.



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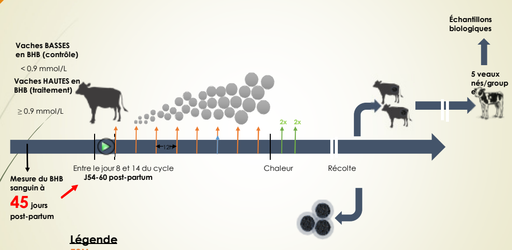
Objectifs de la recherche

- Déterminer l'effet d'un **bilan énergétique négatif au jour 60 post-partum**
  - sur le **développement embryonnaire**
  - sur le **transcriptome embryonnaire** (expression des gènes 40,000)
  - sur le **méthylome embryonnaire** (Methylation de l'ADN 400,000 sites)
- Identifier des **marqueurs potentiels** pour les génisses à la naissance

18

Dispositif expérimental

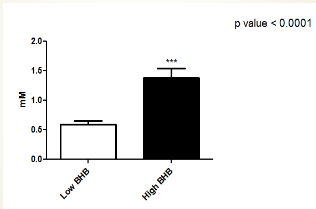


Légende
FSH → Recrutement des follicules
Cloprosténol → Éliminer la présence du corps jaune
IA (semence sexée)

(24 vaches Holstein ont été classées au jour 45 selon le niveau de BHB sanguin pour ensuite être superovulées et récoltées au jour 7

19 Niveau de BHB sanguin selon les groupes

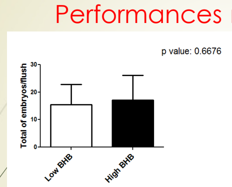
Variation entre 0.1 et 0.8
Moyenne: 0.59

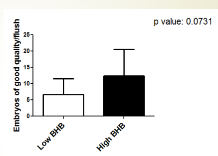


Niveaux moyens de BHB selon les 2 groupes

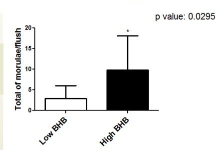
Variation entre 0.9 et 2.2
Moyenne: 1.38

20 Performances reproductives





Nombre et qualité des embryons selon le classement en BHB



Retard ?

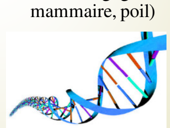
21 Dispositif expérimental

Analyse transcriptomique

- Niveau de transcription des ARNm dans la cellule
- Indice de la synthèse protéique
- Réponse immédiat à l'environnement
- Vérification de gènes cibles par qPCR

Analyse épigénétique

- Méthylation de l'ADN
  - Persistance des marqueurs (placenta, cordon, sang, glande mammaire, poil)



22

Comparaison des blastocystes (expression de gènes)

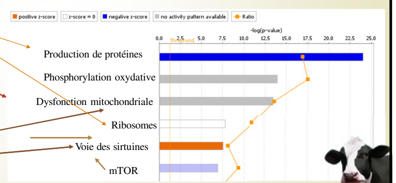
consequences

Transcription inhibée

Problèmes mitochondriaux

mTOR et métabolisme énergétique

Voies biologiques les plus sollicitées

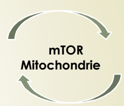


- Ingenuity Pathway Analysis (IPA)

23

mTOR et la mitochondrie

- Interaction directe avec la mitochondrie
- Son altération affecte:
  - la consommation en O2
  - la capacité oxydative de la cellule
  - impliqué dans la balance entre la glycolyse et le métabolisme aérobique
- Existence d'une signalisation rétrograde
  - Équilibre énergétique



Probablement nécessaire pour l'équilibre énergétique et pour réguler la demande énergétique en lien avec la croissance cellulaire

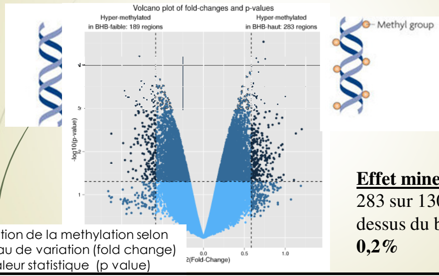
24

Lorsqu'on met tout cela ensemble…

- Freinage de la multiplication cellulaire provoquée par un déficit énergétique, l'embryon tente possiblement de survivre grâce à l'autophagie
  - On économise les réserves!
  - Altération des mécanismes au niveau mitochondrial
- Signature transcriptomique similaire à des embryons provenant de génisses toujours en croissance (8 mois) (Morin-Doré et al., 2017)

25

Résultats : Épigénétique



Distribution de la methylation selon le niveau de variation (fold change) et la valeur statistique (p value)

Effet mineur
283 sur 130,000 probes au-dessus du background soit **0,2%**

26

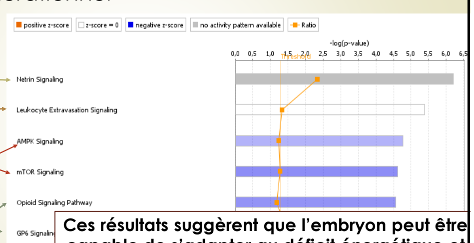
Épigénétique et impact intergénérationnel

Développement cellulaire

Inflammation

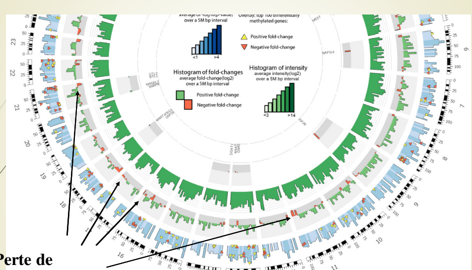
régulation énergétique

Réponse au stress



Ces résultats suggèrent que l'embryon peut être capable de s'adapter au déficit énergétique et de conserver ces modifications jusqu'à l'âge adulte.

27

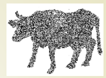


Perte de méthylation au niveau des télomères

Représentation par chromosome des différences de méthylation pour mettre en évidence une hypomethylation des télomères (bouts), comme dans les cas de cancer

28

Conclusion partie génomique



- La balance énergétique négative aurait un **effet** caractéristique **sur l'embryon via**:
  - une **signature spécifique**
    - Transcriptomique : immédiate
    - Épigénétique possiblement à log terme
    - force l'embryon a **économiser son énergie**

Pourrait faire une génisse programmée métaboliquement

Intéressant de repousser la période d'attente volontaire chez les vaches en déficit énergétique de 60 à 120 jours post-partum?

Voir affiche

Catherine Couture[1], Véronique Ouellet[1], Débora Santschi[2], Yasmin Schuermann[2], Victor Cabrera[3], René Roy[2], Marc-André Sirard[1] et Edith Charbonneau[1].

[1]Département des sciences animales, Université Laval, Québec
[2]Lactanet, centre d'expertise en production laitière, Québec.
[3]Department of dairy science, University of Wisconsin, Madison

Conclusion

Prolongé la période d'attente volontaire pour les vaches positives en BHB

Impact négatif:
- ↓ Production de laitière annuelle par vache
- ↓ Vente des veaux
- ↑ Charges variables des vaches

Impact positif:
- ↓ frais de reproduction et d'alimentation
- ↓ frais vétérinaire
- ↑ Prix du lait

- Sachant que l'impact économique est négligeable, pourquoi ne pas le faire?


Questions?
Merci à nos partenaires!
CRIBIQ
Novalait
Catalyseur de recherche
Lactanet
Centre de recherche en reproduction, développement et santé intergénérationnelle
CRSAD
Fonds de recherche Nature et technologies
Québec
$

Symposium sur les bovins laitiers

Le mardi 29 octobre 2019
Centrexpo Cogeco, Drummondville

Je suis chef d'entreprise

Simon Lefebvre, B.Sc.A., agroéconomie, producteur, Ferme Gerville inc.
Karine Phaneuf, M.Sc., agr. CRHA, conseillère en ressources humaines,
Fédération de l'UPA de la Chaudière-Appalaches, Centre de services de Sainte-Marie
Marcel Thuot, fondateur et president du Conseil, Techno Diesel,
Entrepreneur-Entraineur, École d'Entrepreneurship de Beauce et
ancien président du Groupement des chefs d'entreprise

CRAAQ
Comité bovins laitiers

Symposium sur les bovins laitiers

Le mardi 29 octobre 2019

Centrexpo Cogeco, Drummondville

Consommation de produits laitiers et santé : qui dit vrai?

Benoît Lamarche, Ph.D., chercheur et responsable de l'Unité d'investigation nutritionnelle clinique, INAF, Université Laval

*Ce qui suit sont des articles auxquels M. Benoît Lamarche a collaboré et qui sont en lien avec le sujet abordé.

CRAAQ
Comité bovins laitiers

REVIEW

Systematic Review of the Association between Dairy Product Consumption and Risk of Cardiovascular-Related Clinical Outcomes[1–3]

Jean-Philippe Drouin-Chartier,[4] Didier Brassard,[4] Maude Tessier-Grenier,[4] Julie Anne Côté,[5] Marie-Ève Labonté,[6] Sophie Desroches,[4] Patrick Couture,[4,7] and Benoît Lamarche[4]*

[4]Institute of Nutrition and Functional Foods, Laval University, Quebec City, Quebec, Canada; [5]Institut Universitaire de Cardiologie et de Pneumologie de Québec, Quebec City, Quebec, Canada; [6]Department of Nutritional Science, Faculty of Medicine, University of Toronto, Toronto, Ontario, Canada; and [7]CHU de Québec-Université Laval, Quebec City, Quebec, Canada

ABSTRACT

The objective of this systematic review was to determine if dairy product consumption is detrimental, neutral, or beneficial to cardiovascular health and if the recommendation to consume reduced-fat as opposed to regular-fat dairy is evidence-based. A systematic review of meta-analyses of prospective population studies associating dairy consumption with cardiovascular disease (CVD), coronary artery disease (CAD), stroke, hypertension, metabolic syndrome (MetS), and type 2 diabetes (T2D) was conducted on the basis of the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) statement. Quality of evidence was rated by using the Grading of Recommendations Assessment, Development, and Evaluation scale. High-quality evidence supports favorable associations between total dairy intake and hypertension risk and between low-fat dairy and yogurt intake and the risk of T2D. Moderate-quality evidence suggests favorable associations between intakes of total dairy, low-fat dairy, cheese, and fermented dairy and the risk of stroke; intakes of low-fat dairy and milk and the risk of hypertension; total dairy and milk consumption and the risk of MetS; and total dairy and cheese and the risk of T2D. High- to moderate-quality evidence supports neutral associations between the consumption of total dairy, cheese, and yogurt and CVD risk; the consumption of any form of dairy, except for fermented, and CAD risk; the consumption of regular- and high-fat dairy, milk, and yogurt and stroke risk; the consumption of regular- and high-fat dairy, cheese, yogurt, and fermented dairy and hypertension risk; and the consumption of regular- and high-fat dairy, milk, and fermented dairy and T2D risk. Data from this systematic review indicate that the consumption of various forms of dairy products shows either favorable or neutral associations with cardiovascular-related clinical outcomes. The review also emphasizes that further research is urgently needed to compare the impact of low-fat with regular- and high-fat dairy on cardiovascular-related clinical outcomes in light of current recommendations to consume low-fat dairy. *Adv Nutr* 2016;7:1026–40.

Keywords: dairy, milk, cheese, yogurt, cardiovascular disease, coronary artery disease, stroke, hypertension, metabolic syndrome, type 2 diabetes

Introduction

The consumption of dairy, particularly low-fat dairy, is advocated in most dietary guidelines around the world. The main argument supporting the recommendation to consume low-fat dairy is that high plasma LDL-cholesterol concentrations are a key risk factor for coronary artery disease (CAD)[8] and that regular- and high-fat dairy foods are a major source

[1] J-PD-C is a recipient of doctoral scholarships from the Canadian Institute of Health Research and the Fonds de Recherche du Québec – Santé. JAC is a recipient of the Alexander-Graham-Bell doctoral scholarship from the Natural Sciences and Engineering Research Council of Canada. M-EL is a recipient of a Canadian Institutes of Health Research Fellowship (MFE-140953). This review was supported in part by an unrestricted grant from the Dairy Research Consortium (Dairy Farmers of Canada, Centre National Interprofessionnel de l'Économie Laitière, the Dairy Research Institute, Dairy Australia Ltd., the Dutch Dairy Association (NZO), the Danish Dairy Research Foundation, as well as by the Chair of Nutrition at Laval University.

[2] Author disclosures: D Brassard, M Tessier-Grenier, JA Côté, and M-È Labonté, no conflicts of interest. B Lamarche is Chair of Nutrition at Laval University. This Chair is supported by unrestricted endowments from the Royal Bank of Canada, Pfizer, and Provigo/Loblaws. He has received funding in the last 5 y for his research from the Canadian Institutes of Health Research (CIHR), Natural Sciences and Engineering Research Council of Canada, Agriculture and Agrifood Canada, the Canola Council of Canada, Dairy Farmers of Canada (DFC), the Dairy Research Institute (DRI), Atrium Innovations, the Danone Institute, and Merck Frosst. He has received speaker honoraria over the last 5 y from DFC and the DRI. He is Chair of the Expert Scientific Advisory Panel of DFC and of the ad hoc committee on saturated fat of the Heart and Stroke Foundation of Canada. P Couture has received funding in the last 5 y from the CIHR, Agriculture and Agrifood Canada, DFC, DRI, Merck Frosst, and Kaneka Corporation. S Desroches has received funding in the last 5 y from the CIHR and the Danone Institute. J-P Drouin-Chartier has received speaker honoraria over the last year from DFC.

  Adv Nutr 2016;7:1026–40; doi:10.3945/an.115.011403.

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of cholesterol-increasing SFAs (1, 2). Although there is little doubt about the LDL cholesterol–increasing effects of SFAs per se, the extent to which the consumption of different forms of dairy products, including regular- and low-fat dairy, influences the risk of cardiovascular-related clinical outcomes has not yet been comprehensively examined, to our knowledge.

In an attempt to shed light on this complex issue, we have undertaken a systematic review to answer the following 2 key questions: *1*) is dairy consumption detrimentally, neutrally, or beneficially associated with cardiovascular-related clinical outcomes, and *2*) is the recommendation to consume low-fat, as opposed to regular- or high-fat dairy, evidence-based? This review focuses primarily on existing meta-analyses of prospective epidemiologic studies of dairy intake and cardiovascular-related clinical outcomes, that is, cardiovascular disease (CVD), coronary artery disease (CAD), stroke, hypertension, metabolic syndrome (MetS), and type 2 diabetes (T2D). Prospective epidemiologic studies of dairy intake and clinical outcomes of interest that were not included in published meta-analyses were also further reviewed. The association between dairy consumption and cardiovascular-related outcomes was ascertained while considering total and individual dairy (milk, yogurt, cheese), irrespective of fat content; regular- or high-fat and low-fat dairy as per the definition by investigators in the various studies; and finally, fermented dairy when possible. Butter is generally not considered part of the dairy food category in most dietary guidelines and thus was not included in this analysis. We believe that this extensive review encompasses all available epidemiologic evidence relating dairy product consumption to cardiovascular-related health outcomes. No a priori hypothesis was established.

Methods

Full details of the methods used are presented in the **Supplemental Methods**. Briefly, this systematic review was conducted according to the PRISMA (Preferred Reporting Items for Systematic Review and Meta-Analysis) statement (**Supplemental Table 1**) (3). We first screened PubMed and Embase databases to identify meta-analyses of prospective cohort studies on the association between dairy product consumption (any form) and cardiovascular-related clinical outcomes (e.g., CVD, CAD, stroke, hypertension, MetS, and T2D). Meta-analyses of data from cross-sectional or case-control studies were not included. Individual prospective cohort studies that had not been included in the retrieved meta-analyses were also identified and reviewed. Two authors independently undertook the literature search in May 2015 with the use of keywords provided in **Supplemental Table 2**. The search was repeated in November 2015 before the original submission of the article and updated in March 2016 during the revision process.

The quality of each meta-analysis was evaluated and scored by 2 authors (J-PD-C and BL) independently by using the Meta-analysis Of Observational Studies in Epidemiology (MOOSE) checklist (4), as detailed in the Supplemental Methods. The interrater reliability in the quality scoring was good (*r* = 0.79). Disagreement between raters (scores differing by >15%) was resolved by discussion. Meta-analyses with scores >80% were considered to be of good quality. Studies with scores between >60% and ≤80% were considered to be of moderate quality. Finally, studies with scores ≤60% were considered to be of poor quality. The complete list of meta-analyses included in this systematic review and their quality rating is presented in **Table 1**. The flow of retrieved meta-analyses and prospective cohort studies during the literature search is shown in **Supplemental Tables 3** and **4**.

The quality of evidence relating dairy intake to cardiovascular-related clinical outcomes was assessed through consensus from 2 authors (J-PD-C and BL) by using an adaptation of the Grading of Recommendations Assessment, Development, and Evaluation (GRADE) scale (26), as detailed in **Supplemental Table 5**. According to the GRADE scale (27, 28), high-quality evidence defines a situation in which "we are very confident that the true effect lies close to that of the estimate of the effect." Moderate-quality evidence indicates that "we are moderately confident in the effect estimate. The true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different." Low-quality evidence indicates that "our confidence in the effect estimate is limited. The true effect may be substantially different from the estimate of the effect." Very low-quality evidence indicates that "we have very little confidence in the effect estimate. The true effect is likely to be substantially different from the estimate of the effect." Information pertaining specifically to associations supported by low- or very low-quality evidence has been included in the **Supplemental Information** in order to shorten the review. Setting this information as online supporting material should not be seen as a biased way to present the evidence, and we emphasize in each section of this review the importance of conducting more research in instances in which we are lacking high-quality evidence.

Dairy and Cardiovascular-Related Clinical Outcomes

CVD

Total dairy and CVD. In 2013, O'Sullivan et al. (15) evaluated the association between total dairy intake and CVD mortality (**Supplemental Table 6**). Total dairy intake showed no association with CVD mortality rates (RR: 0.87; 95% CI: 0.62, 1.20). The authors reported no evidence of heterogeneity between studies and no publication bias. In their 2015 meta-analysis, Qin et al. (19) reported an inverse association between total dairy consumption and the risk of nonfatal CVD (RR: 0.88; 95% CI: 0.81, 0.96). There was no evidence of significant heterogeneity between studies or publication bias. Finally, Alexander et al. (24) recently reported no association between total dairy intake and CVD (RR: 0.85; 95% CI: 0.75, 1.04), with significant heterogeneity between studies but no publication bias. Two (15, 19) of the 3 meta-analyses were based on different pools of cohort studies with only 1 study in common. Associations differed slightly according to whether CVD mortality (15) or CVD incidence (19, 24) was considered. The search retrieved 1 additional cohort study (29) that had not been included in these meta-analyses and that reported no significant association between total dairy intake and risk of fatal CVD (**Supplemental Table 7**).

In summary, risk estimates based on 3 meta-analyses predicted either a favorable or neutral association between total dairy consumption and CVD risk. Thus, there is moderate-quality evidence that total dairy consumption is neutral in terms of CVD risk (**Table 2**).

Dairy fat and risk of CVD. The quality of evidence relating dairy fat intake to CVD risk is judged to be very low (Table 2), when considering the lack of meta-analyses and the limited

[3] Supplemental Methods, Supplemental Tables 1–15, and Supplemental Information are available from the "Online Supporting Material" link in the online posting of the article and from the same link in the online table of contents at http://advances.nutrition.org.

*To whom correspondence should be addressed. E-mail: benoit.lamarche@fsaa.ulaval.ca.

[8] Abbreviations used: CAD, coronary artery disease; CVD, cardiovascular disease; GRADE: Grading of Recommendations Assessment, Development, and Evaluation; IHD, ischemic heart disease; MetS, metabolic syndrome; MOOSE, Meta-analysis Of Observational Study in Epidemiology; T2D, type 2 diabetes; TFA, *trans* fatty acid.

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TABLE 1 List of meta-analyses included in this review and their quality score and funding source

First author, year (reference)	Quality score,[1] %	Funding source
Elwood et al., 2004 (5)	53	University of Wales College of Medicine and Bristol University, Food Standards Agency
Elwood et al., 2008 (6)	54	No funding
Elwood et al., 2010 (7)	54	No funding
Soedamah-Muthu et al., 2011 (8)	74	Dutch Dairy Association (unrestricted)
Tong et al., 2011 (9)	60	National Natural Science Foundation of China
Bendsen et al., 2011 (10)	80	Arla Food Amba
Ralston et al., 2012 (11)	69	National Health and Medical research Council of Australia
Soedamah-Muthu et al., 2012 (12)	71	Dutch Dairy Association (unrestricted), Global Dairy Platform
Aune et al., 2013 (13)	69	Liaison Committee between the Central Norway Regional Health Authority and the Norwegian University of Science and Technology
Gao et al., 2013 (14)	80	National Natural Science Foundation of China
O'Sullivan et al., 2013 (15)	83	National Health and Medical research Council of Australia
Chen et al., 2014 (16)	54	NIH
Chowdhury et al., 2014 (17)	100	British Heart Foundation, Medical Research Council, Cambridge National Institute for Health Research Biomedical Research Centre, Gates Cambridge
Hu et al., 2014 (18)	71	Not indicated
Qin et al., 2015 (19)	64	Nestec Ltd. [Nestlé R&D (China) Ltd.]
de Souza et al., 2015 (20)	77	WHO
Larsson et al., 2015 (21)	66	Young Scholars Award Grant from the Strategic Research Area in Epidemiology, Karolinska Institutet
Chen et al., 2015 (22)	67	Yili Innovation Center, Inner Mongolia Yili Industrial Group Co., Ltd.
Kim and Je, 2016 (23)	67	Basic Science Research Program of the National Research Foundation of Korea, Ministry of Science, Information and Communication Technology and Future Planning
Alexander et al., 2016 (24)	67	Dairy Research Institute
Gijsbers et al., 2016 (25)	73	Wageningen University

[1] Quality score was calculated according to the MOOSE (Meta-analysis Of Observational Study in Epidemiology) checklist.

number of cohort studies on this topic, the diversity of the methods used to assess dairy fat intake, and the inconsistent conclusions among studies (see Supplemental Information for details).

Milk and risk of CVD. Despite the fact that the association between milk consumption and CVD risk has been evaluated in several meta-analyses of cohort studies (Supplemental Table 6), the direction of this association cannot be established with any confidence at this point because the estimates of effects remain uncertain (very low quality of evidence; Table 2). The Supplemental Information provides detailed information on this assessment. Future meta-analyses will have to include data from all published studies to better reflect these associations, with particular consideration of heterogeneity.

Cheese and risk of CVD. The search retrieved 2 meta-analyses of the association between cheese consumption and CVD risk (Supplemental Table 6). O'Sullivan et al. (15) (RR: 1.00; 95% CI: 0.81, 1.24; no heterogeneity and no publication bias) and Alexander et al. (24) (RR: 0.89; 95% CI: 0.78, 1.01; no heterogeneity, publication bias not assessed) reported no significant association between cheese intake and CVD. One additional prospective study was retrieved, which also reported no association between CVD risk and the consumption of regular-fat or low-fat cheese (30) (Supplemental Table 7). On the basis of data from 2 meta-analyses that showed consistent results, there is high-quality evidence that cheese intake is not associated with the risk of CVD (Table 2).

Yogurt and risk of CVD. Alexander et al. (24) in their meta-analysis reported no significant association between yogurt consumption and CVD risk (RR: 0.93; 95% CI: 0.78, 1.12). Heterogeneity and publication bias were not assessed. Of note, the authors did not identify references of individual studies included in this particular analysis and did not provide this information after being contacted. In summary, evidence suggests that the association between yogurt consumption and CVD risk is neutral, and this assessment is based on moderate-quality evidence (Table 2).

Fermented dairy and risk of CVD. The association between the consumption of fermented dairy and the risk of CVD has not yet been meta-analyzed, to our knowledge. In that context, the assessment of the association between the consumption of fermented dairy and CVD risk is based on very low-quality evidence and thus remains uncertain at this point (Table 2). Additional information is available in the Supplemental Information.

Dairy and risk of CVD—summary. The association between dairy consumption in various forms and CVD risk has been evaluated in a limited number of meta-analyses (**Figure 1**). Scientific evidence of moderate-to-high quality indicates that intakes of total dairy, cheese, and yogurt are neutral in terms of CVD risk. The quality of evidence relating high-fat dairy, low-fat dairy, milk, and fermented dairy intake to CVD risk is considered to be very low and hence no conclusion can be drawn with any confidence at this point (Table 2).

TABLE 2 Summary of the association between dairy product consumption and clinical outcomes, with assessment of quality of evidence[1]

	CVD	CAD	Stroke	Hypertension	MetS	T2D
Total dairy	Neutral	Neutral	Favorable	Favorable	Favorable	Favorable
	Moderate	High	Moderate	High	Moderate	Moderate
Regular- or high-fat dairy	Uncertain	Neutral	Neutral	Neutral	Uncertain	Neutral
	Very low	High	Moderate	Moderate	Very low	Moderate
Low-fat dairy	Uncertain	Neutral	Favorable	Favorable	Uncertain	Favorable
	Very low	High	Moderate	Moderate	Very low	High
Milk	Uncertain	Neutral	Neutral	Favorable	Favorable	Neutral
	Very low	Moderate	Moderate	Moderate	Moderate	Moderate
Cheese	Neutral	Neutral	Favorable	Neutral	Uncertain	Favorable
	High	Moderate	Moderate	High	Very low	Moderate
Yogurt	Neutral	Neutral	Neutral	Neutral	Uncertain	Favorable
	Moderate	Moderate	Moderate	Moderate	Very low	High
Fermented dairy	Uncertain	Uncertain	Favorable	Neutral	Uncertain	Neutral
	Very low	Very low	Moderate	Moderate	Very low	Moderate

[1] Each of these associations is described in detail in the text. The association between dairy intake (any form) and the onset of any clinical outcome is described as "unfavorable" (increased risk with dairy intake), "neutral" (no association between dairy intake and risk), or "favorable" (reduced risk with increased intake of dairy). The quality of evidence (very low, low, moderate, or high) is described by using the GRADE grading system as described in Supplemental Table 5. High-quality evidence defines a situation in which "we are very confident that the true effect lies close to that of the estimate of the effect." Moderate-quality evidence indicates that "we are moderately confident in the effect estimate. The true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different." Low-quality evidence indicates that "our confidence in the effect estimate is limited. The true effect may be substantially different from the estimate of the effect." Very low-quality evidence indicates that "we have very little confidence in the effect estimate. The true effect is likely to be substantially different from the estimate of the effect." CAD, coronary artery disease; CVD, cardiovascular disease; GRADE, Grading of Recommendations Assessment, Development, and Evaluation; MetS, metabolic syndrome; T2D, type 2 diabetes.

CAD

Total dairy and risk of CAD. Soedamah-Muthu et al. (8) in their meta-analysis reported no significant association between total dairy intake and the risk of CAD (RR: 1.02; 95% CI: 0.93, 1.11; **Supplemental Table 8**). There was no evidence of heterogeneity between studies and publication bias was not assessed. Qin et al. (19) also reported no significant association between total dairy and CAD risk (RR: 0.94; 95% CI: 0.82, 1.07). There was significant heterogeneity between studies, but sensitivity analysis revealed little influence on the global interpretation of the data. There was no evidence of publication bias in the meta-analysis by Qin et al. (19). Finally, the recent meta-analysis by Alexander et al. (24) reported no significant association between total dairy intake and CAD risk (RR: 0.91; 95% CI: 0.80, 1.04). There was significant heterogeneity between studies but no evidence of publication bias. The search retrieved 1 small additional prospective cohort study (31) in which total dairy intake and CAD were not associated (Supplemental Table 7). In sum, there is high-quality evidence from 3 meta-analyses (8, 19, 24) that total dairy consumption is not associated with CAD risk (Table 2).

Dairy fat and risk of CAD. In a dose-response meta-analysis of 4 prospective cohort studies, Soedamah-Muthu et al. (8) found no significant association between the intake of high-fat dairy and CAD risk (RR: 1.04; 95% CI: 0.89, 1.21; Supplemental Table 8) and between low-fat dairy intake and total CAD risk (RR: 0.93; 95% CI: 0.74, 1.17). Potential publication bias was not assessed, but there was no evidence of heterogeneity between studies. The meta-analysis by Qin et al. (19) came to the same conclusion for the analysis of both regular- and high-fat dairy and low-fat dairy. The authors did not provide the reference list specific to each of those analyses in the publication or after being contacted. In their meta-analysis, Alexander et al. (24) reported a neutral association between high-fat dairy intake and CAD risk (RR: 1.08; 95% CI: 0.93, 1.19) and an inverse association between low-fat dairy intake and CAD risk (RR: 0.90; 95% CI: 0.82, 0.98). Heterogeneity and publication bias were not assessed.

Dairy fat contains naturally occurring *trans* fatty acids (TFAs), mostly vaccenic acid (*trans*-18:1ω-7). In 2011, Bendsen et al. (10) published a meta-analysis of 4 cohort studies that assessed the association between the intake of TFAs from industrial and ruminant origins and CAD risk. Intakes of TFAs from ruminants showed no significant association with CAD risk (RR: 0.92; 95% CI: 0.76, 1.11). There was no evidence of heterogeneity between studies. Results from the more recent meta-analysis by de Souza et al. (20) also indicated that there was no association between ruminant TFA intake and CAD risk (RR: 0.93; 95% CI: 0.73, 1.18). In addition, de Souza et al. reported null associations between intakes of the dairy-specific FAs pentadecanoic acid (15:0; RR: 0.94; 95% CI: 0.44,

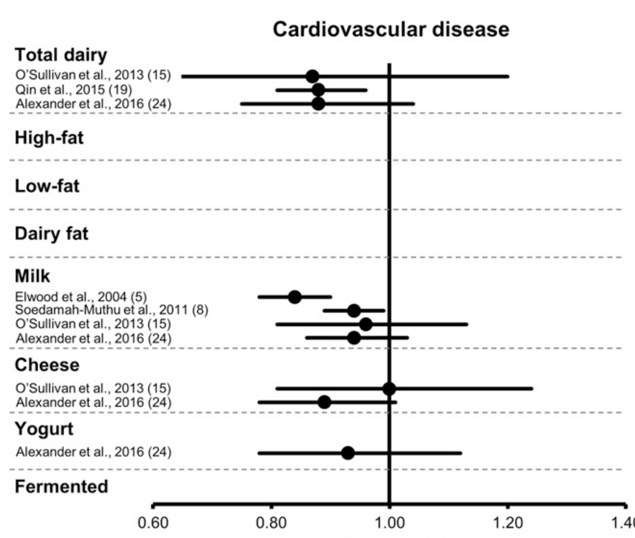

FIGURE 1 Forest plot of RRs from meta-analyses of prospective cohort studies on the association between dairy intake and cardiovascular disease risk, with their 95% CIs. Each symbol represents data from an individual meta-analysis.

2.06) and heptadecanoic acid (17:0; RR: 0.92; 95% CI: 0.82, 1.03) and CAD risk. The authors reported significant heterogeneity between studies in the case of the association between the intake of pentadecanoic acid specifically and CAD risk, although publication bias was not evaluated (20). Finally, Chowdhury et al. (17) in their meta-analysis reported no significant association between plasma concentrations of pentadecanoic acid and CAD (RR: 0.94; 95% CI: 0.67, 1.32), whereas concentrations of heptadecanoic acid were inversely associated with the risk of CAD (RR: 0.77; 95% CI: 0.63, 0.93). Plasma concentrations of palmitoleic acid (*cis*-16:1ω-7) showed no association with CAD risk (RR: 0.96; 95% CI: 0.86, 1.08). Publication bias was not assessed specifically for these associations, and there was moderate heterogeneity between studies.

In summary, high-quality evidence from several meta-analyses based on either self-reported dairy fat intake (8, 19) or on biomarkers of dairy fat intake (10, 17, 20) suggests that high intakes of dairy fat are not associated with CAD risk (Table 2). There is also high-quality evidence indicating that the consumption of low-fat dairy products is not associated with the risk of CAD.

Milk and risk of CAD. Elwood et al. (5–7) published 3 meta-analyses to assess the association between milk consumption specifically and CAD risk (Supplemental Table 8). In 2004 (5), the authors reported no significant association risk (RR: 0.84; 95% CI: 0.74, 1.03), whereas in 2008 they showed that high compared with low milk consumption was associated with a reduced risk of CAD (RR: 0.84; 95% CI: 0.76, 0.93) (6). In their 2010 meta-analysis (7), high compared with low consumption of milk was also associated with a significantly lower risk of CAD (RR: 0.92; 95% CI: 0.80, 0.99). There was no evidence of heterogeneity between studies, and publication bias was not assessed in any of the 3 meta-analyses, all of which had a low-quality score on the basis of the MOOSE scale. Soedamah-Muthu et al. (8) examined the dose-response relation between milk intake and total CAD risk. Increased consumption of milk showed no association with CAD risk (RR: 0.92; 95% CI: 0.80, 0.99), without evidence of heterogeneity between studies. Publication bias was not assessed. In their recent meta-analysis, Alexander et al. (24) also reported no significant association between milk consumption and CAD risk (RR: 1.05; 95% CI: 0.95, 1.16). The authors did not provide the list of studies included in this particular analysis and did not provide this information after being contacted.

Overall, considering some degree of inconsistency among available meta-analyses and based on our adapted GRADE criteria (see Supplemental Methods), increased milk intake is suggested to show no association with the risk of CAD, and this is supported by moderate-quality evidence (Table 2). Whether skimmed or low-fat milk is more favorably associated with the risk of CAD than regular-fat milk has yet to be determined.

Cheese and risk of CAD. In 2010, Elwood et al. (7) reported no significant association between cheese intake and the risk of ischemic heart disease [(IHD); RR: 0.90; 95% CI: 0.79, 1.03; Supplemental Table 8]. However, results are confounded by the fact that stroke was combined with IHD as a study endpoint, which limits their interpretation. Publication bias was not assessed, although there was no evidence of heterogeneity between the 2 studies included in the meta-analysis by Elwood et al. (7). Qin et al. (19) meta-analyzed 7 prospective cohort studies on the association between cheese consumption and CAD risk. The authors did not provide the list of studies included in this particular analysis. Cheese consumption tended to be inversely associated with CAD risk (RR: 0.84; 95% CI: 0.74, 1.00). There was no evidence of significant heterogeneity between studies and no publication bias. Alexander et al. (24), on the basis of 5 prospective cohort studies, concluded that there was a significant inverse association between cheese consumption and CAD risk (RR: 0.82; 95% CI: 0.72, 0.93).

In summary, cheese intake shows no significant association with the risk of CAD (Table 2). The evidence supporting this observation is considered to be of moderate quality because of the inconsistent results among meta-analyses. There is, to date, no evidence that indicates that low-fat cheese may be differentially associated with the risk of CAD compared with regular-fat cheese.

Yogurt and risk of CAD. In the meta-analyses by Qin et al. (19) and by Alexander et al. (24), yogurt consumption showed no significant association with the risk of CAD (Supplemental Table 8). Our search retrieved 2 additional prospective cohort studies (31, 32), which may have been included in the recent meta-analysis by Alexander et al. (24). This remains unclear, because the authors did not provide the list of studies included in their meta-analysis. In these individual prospective cohort studies, high compared with low intakes of yogurt were also not associated with fatal or incident CAD risk (Supplemental Table 7).

The evidence that suggests a neutral association between yogurt consumption and CAD risk appears to be consistent, although existing meta-analyses lack important information. For this reason, we suggest that this neutral association between yogurt consumption and CAD risk is supported by moderate-quality evidence (Table 2). The difference between regular-fat and low-fat yogurt in terms of CAD risk cannot be determined at this point.

Fermented dairy and risk of CAD. The association between the consumption of fermented dairy and the risk of CAD remains uncertain (Table 2), because only evidence of insufficient quality is available (Supplemental Table 7). Additional information is available in the Supplemental Information.

Dairy products and CAD—summary. On the basis of available meta-analyses and prospective cohort studies, there is high-quality evidence that total dairy, high-fat dairy, and low-fat dairy consumption shows no association with the risk of CAD (**Figure 2**). The neutral association between intakes of milk, cheese, and yogurt and CAD risk is supported by evidence judged to be of moderate quality, and the association between fermented dairy consumption and CAD risk remains uncertain because of limited evidence (Table 2).

Stroke

Total dairy and risk of stroke. Hu et al. (18) assessed the relation between total dairy intake and the risk of stroke on the basis of data from 18 cohort studies (**Supplemental Table 9**). Total dairy intake was inversely associated with the risk of stroke (RR: 0.88; 95% CI: 0.82, 0.94). There was no evidence of publication bias, but there was significant heterogeneity between studies. However, the inverse association between total dairy intake and the risk of stroke remained significant when the 3 studies responsible for heterogeneity were excluded in sensitivity analyses. Qin et al. (19) in their meta-analysis of 12 cohort studies also showed that total dairy consumption was associated with a significant reduction in stroke risk (RR: 0.87; 95% CI: 0.77, 0.99). The authors reported significant heterogeneity between studies as well as significant publication bias. Alexander et al. (24) also recently reported an inverse association between total dairy intake and stroke risk (RR: 0.91; 95% CI: 0.83, 0.99), with again, significant heterogeneity between individual studies. Of note, all prospective studies included in the meta-analysis by Qin et al. (19) and Alexander et al. (24) were also included in the meta-analysis by Hu et al. (18). One additional cohort study (31) reported no association between total dairy intake and stroke risk (Supplemental Table 7). This study was very small compared with existing data from previous meta-analyses and therefore unlikely to have an impact on the reported pooled risk estimates from existing meta-analyses.

In summary, the inverse association between total dairy intake and the risk of stroke appears to be robust. However, because results from the 3 meta-analyses are based on a relatively homogeneous pool of cohort studies, we suggest that this favorable association between intake of total dairy and risk of stroke is based on moderate-quality evidence.

Dairy fat and risk of stroke. In the meta-analysis by Hu et al. (18), no association was found between the intake of high-fat dairy (as per the definition by the authors) and the risk of stroke (RR: 0.96; 95% CI: 0.92, 1.01), whereas the intake of low-fat dairy products was associated with a 9% lower risk of stroke (RR: 0.91; 95% CI: 0.85, 0.97; Supplemental Table 9). There was no evidence of heterogeneity between studies or of publication bias. Qin et al. (19) reached similar conclusions for high-fat (RR: 0.95; 95% CI: 0.83, 1.08) and low-fat (RR: 0.93; 95% CI: 0.88, 0.99) dairy. The authors did not identify the individual cohort studies used in these specific analyses (19). However, we suspect that most of the studies used by Qin et al. were included in the meta-analysis by Hu et al., because this was the case when both groups assessed total dairy. Alexander et al. (24) in their recent meta-analysis reported inverse associations between both high-fat

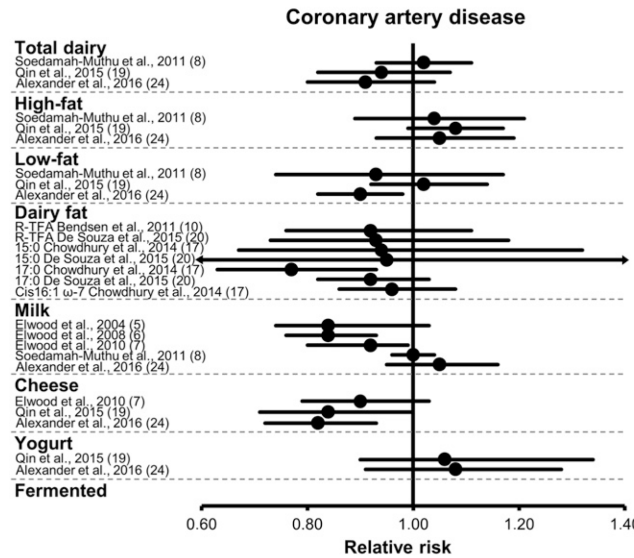

FIGURE 2 Forest plot of RRs from meta-analyses of prospective cohort studies on the association between dairy intake and coronary artery disease risk, with their 95% CIs. Each symbol represents data from an individual meta-analysis. Arrows indicate that the 95% CIs exceed the figure scale. R-TFA, ruminant *trans* fatty acids.

dairy intake (RR: 0.91; 95% CI: 0.84, 0.99) and low-fat dairy intake (RR: 0.90; 95% CI: 0.83, 0.96) and the risk of stroke. In additional prospective cohort studies (31, 33), high intakes of dairy fat or low-fat dairy were not associated with stroke risk (Supplemental Table 7).

In summary, because data from published meta-analyses may be derived mostly from the same pool of cohort studies, we conclude that there is moderate-quality evidence that the intake of regular- and high-fat dairy is not associated with the risk of stroke. On the other hand, the consumption of low-fat dairy is favorably associated with stroke risk on the basis of moderate-quality evidence (Table 2).

Milk and risk of stroke. Elwood et al. (5–7) published 3 meta-analyses relating milk consumption to stroke risk. Articles published in 2004 (5), 2008 (6), and 2010 (7) all reported a reduced risk of stroke associated with high compared with low milk consumption (Supplemental Table 9). Heterogeneity between studies was observed in the 2010 meta-analysis (7), and publication bias was not assessed in any of the 3 meta-analyses. On the other hand, the dose-response meta-analysis of Soedamah-Muthu et al. (8) showed no association between milk consumption and the risk of stroke (RR: 0.87; 95% CI: 0.72, 1.07). There was no evidence of publication bias but significant heterogeneity between studies was observed, with milk intake being associated with a reduced risk of stroke among women but not among men. The degree of adjustment for confounding factors also appeared to attenuate the association between milk intake and risk of stroke. Hu et al. (18) reported no significant association between milk intake and the risk of stroke in their meta-analysis (RR: 0.91; 95% CI: 0.82, 1.01). There was also significant heterogeneity between studies, but further analysis that excluded the 3 studies responsible for this heterogeneity had no impact on the results. There was no evidence of publication bias. Finally, Alexander et al. (24) recently reported no significant association between milk consumption and stroke risk (RR: 0.90; 95% CI: 0.79, 1.02), with significant heterogeneity between studies. The authors did not provide the list of references for this specific analysis.

In summary, 3 meta-analyses by the same group of authors reported a favorable association between milk intake and the risk of stroke, whereas meta-analyses conducted by other groups, including 1 dose-response analysis, reported null associations between milk intake and stroke risk. Thus, milk consumption is not associated with the risk of stroke, which is supported by moderate-quality evidence. There is no evidence to date that skimmed or low-fat milk may be more favorably associated with the risk of stroke than regular-fat milk.

Cheese and risk of stroke. Elwood et al. (7) reported in their meta-analysis no significant association between cheese intake and the risk of IHD and stroke combined (RR: 0.90; 95% CI: 0.79, 1.03). There was significant heterogeneity between studies, and publication bias was not assessed. However, the combined assessment of IHD and stroke and the limited number of cohort studies included ($n = 2$) limit the generalizability of the results. Hu et al. (18) reported a small but significantly lower risk of stroke with cheese consumption (RR: 0.94; 95% CI: 0.89, 0.995). No evidence of publication bias or heterogeneity between studies was found. Qin et al. (19) also reported an inverse association between cheese consumption and stroke risk (RR: 0.91, 95% CI: 0.84, 0.98). Their meta-analysis revealed no significant heterogeneity between studies and no publication bias. Alexander et al. (24), on the basis of data from 4 prospective cohort studies, reported an inverse association between cheese consumption and stroke risk (RR: 0.87; 95% CI: 0.77, 0.99). It is unclear how many cohort studies are common to these meta-analyses because Qin et al. (19) did not provide references for their analysis.

In summary, 3 meta-analyses with relatively large numbers of subjects concluded that cheese consumption is associated with a reduced risk of stroke, whereas a meta-analysis based on only 2 cohort studies with a low-quality score reported a null association. As per our a priori–defined criteria, we suggest that cheese intake is favorably associated with the risk of stroke, and that this is supported by moderate-quality evidence. More studies characterizing the association between regular-fat and low-fat cheese and the risk of stroke are needed.

Yogurt and risk of stroke. Qin et al. (19) meta-analyzed data from prospective cohort studies and reported a null association between yogurt consumption and the risk of stroke (RR: 0.98, 95% CI: 0.92, 1.06). Two additional cohort studies (31, 32) also reported no significant association between yogurt consumption and the risk of stroke (Supplemental Table 7). The available meta-analysis has a relatively good quality score and suggests that yogurt consumption is not associated with the risk of stroke, and this is based on moderate-quality evidence (Table 2).

Fermented dairy and risk of stroke. One meta-analysis (18) showed that intake of fermented dairy was associated with a reduced risk of stroke (RR: 0.80; 95% CI: 0.71, 0.89), without evidence of publication bias or heterogeneity between studies (Supplemental Table 9). It must be stressed that there were only 2 prospective cohort studies included in this meta-analysis and its quality was rated as moderate (Table 1). However, 2 recent prospective cohort studies reported no association between fermented dairy and the risk of stroke (31, 32) (Supplemental Table 7). The large number of individuals in these studies may change the risk estimates when included in an updated meta-analysis.

On the basis of this finding, we suggest that there is moderate-quality evidence that the consumption of fermented dairy is associated with a reduced risk of stroke (Table 2). Indeed, the meta-analysis available is based on only 3 prospective cohort studies and thus risk estimates may change with future studies on this topic. The difference between regular-fat and low- or no-fat yogurt intake in terms of stroke risk is unknown.

Dairy and risk of stroke—summary. Although the consumption of total dairy, low-fat dairy, cheese, and fermented dairy may be associated with a reduced risk of stroke, intakes of regular- and high-fat dairy, yogurt, and milk specifically show no association with stroke risk (Table 2, **Figure 3**). More research is warranted to further examine if the reduced-fat version of a specific dairy product is more favorably associated with the risk of stroke than its regular-fat version.

Hypertension

Total dairy and risk of hypertension. In the meta-analysis by Soedamah-Muthu et al. (12), for every 200-g/d increase in total dairy intake, there was a significant 3% reduction in the risk of hypertension (RR: 0.97; 95% CI: 0.95, 0.99; **Supplemental Table 10**). There was no heterogeneity between studies, and no evidence of publication bias. In the meta-analysis by Ralston et al. (11), total dairy intake was inversely associated with the risk of hypertension (RR: 0.87; 95% CI: 0.81, 0.94). There was no evidence of heterogeneity between studies. Publication bias was not assessed. Four prospective cohort studies were common to both meta-analyses. Six prospective cohort studies were not included in these meta-analyses (**Supplemental Table 11**). Four of these studies (34–37) reported a significant inverse association between total dairy intake and the risk of hypertension, whereas the other 2 reported no significant association (38, 39). Although not all significant, the direction and magnitude of the hypertension risk estimates with total dairy intake in these small prospective cohort studies are comparable to numbers reported in the meta-analyses by Soedamah-Muthu et al. (12) and Ralston et al. (11). Data from these individual cohort

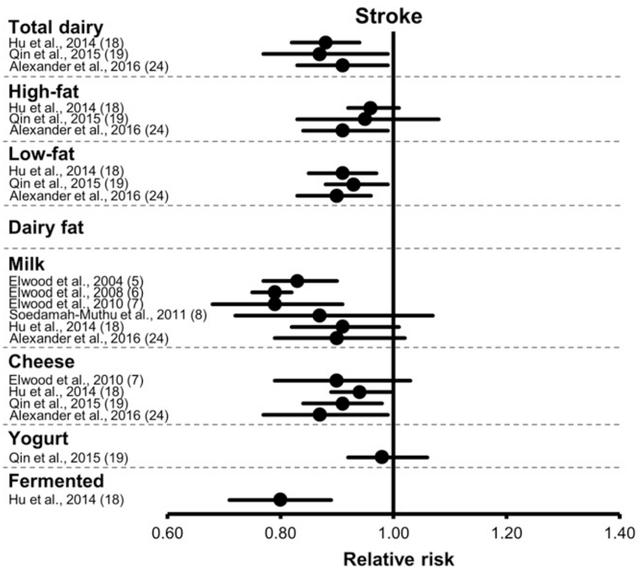

FIGURE 3 Forest plot of RRs from meta-analyses of prospective cohort studies on the association between dairy intake and the risk of stroke, with their 95% CIs. Each symbol represents data from an individual meta-analysis.

studies are therefore unlikely to materially modify risk estimates from available meta-analyses, which are based on combined sample sizes of >40,000 individuals.

Thus, data from available meta-analyses and prospective cohort studies are fairly consistent in suggesting that total dairy consumption is associated with a reduced risk of hypertension (Table 2). This assessment is based on high-quality evidence according to the GRADE system.

Dairy fat and risk of hypertension. Soedamah-Muthu et al. (12) in their meta-analysis (Supplemental Table 10) reported no association between the consumption of high-fat dairy and the risk of hypertension (RR: 0.99; 95% CI: 0.95, 1.03), whereas low-fat dairy intake was associated with a significant reduction in the risk of hypertension (RR: 0.96; 95% CI: 0.93, 0.99). Publication bias was not assessed, and results were not found to be heterogeneous between studies for either the low-fat or the high-fat dairy analysis. Similarly, the consumption of high-fat dairy in the meta-analysis by Ralston et al. (11) showed no association with the risk of hypertension (RR: 1.00; 95% CI: 0.89, 1.11), whereas low-fat dairy consumption was associated with a significant reduction in the risk of hypertension (RR: 0.84; 95% CI: 0.74, 0.95). There was significant heterogeneity between studies but no mention of potential publication bias. All of the studies included in the meta-analysis by Ralston et al. (11) were included in the meta-analysis by Soedamah-Muthu et al. (12). The consumption of high-fat as well as low-fat dairy foods has been associated with a reduced risk of elevated blood pressure or hypertension in some (34, 37), but not all (37, 40), additional prospective cohort studies, depending on how dairy products were categorized (Supplemental Table 11).

Data from meta-analyses and additional prospective cohort studies suggest that the consumption of high-fat dairy is not associated with the risk of hypertension or high blood pressure, whereas low-fat dairy consumption may be associated with a reduced risk of hypertension (Table 2). Evidence supporting this assessment is of moderate quality because the 2 independent meta-analyses are based on essentially the same pool of cohort studies.

Milk and risk of hypertension. In the only meta-analysis available on this topic so far, Soedamah-Muthu et al. (12) showed an inverse association between milk intake and the risk of hypertension (RR: 0.96; 95% CI: 0.94, 0.98; Supplemental Table 10). Potential publication bias was not assessed, but there was no apparent heterogeneity between studies. Additional prospective cohort studies reported either significant inverse associations (34, 39) or null associations (37, 38) between milk consumption and the risk of hypertension (Supplemental Table 11).

On the basis of results from 1 meta-analysis and from additional prospective cohort studies, milk consumption may be associated with a reduced risk of hypertension. The evidence supporting this association is of moderate quality (Table 2). The extent to which reduced-fat milk may be more favorably associated with a reduced risk of hypertension than regular-fat milk is uncertain and needs further consideration in future studies on this topic.

Cheese and risk of hypertension. In the meta-analysis by Soedamah-Muthu et al. (12), cheese consumption showed no significant association with the risk of hypertension (RR: 1.00; 95% CI: 0.98, 1.03; Supplemental Table 10). No evidence of heterogeneity was noted between studies, and publication bias was not assessed. The meta-analysis by Ralston et al. (11) came to similar conclusions (RR: 1.00; 95% CI: 0.89, 1.12). The two meta-analyses had 4 cohort studies in common. Other retrieved prospective cohort studies (34–37, 39) reported no significant association between cheese consumption and hypertension risk (Supplemental Table 11).

In sum, the 2 available meta-analyses and additional cohort studies were consistent in showing no significant association between cheese intake and the risk of hypertension. Thus, there is high-quality evidence that cheese consumption per se is not associated with the risk of hypertension (Table 2). Whether the consumption of low-fat cheese is associated with more favorable blood pressure outcomes than regular-fat cheese is uncertain.

Yogurt and risk of hypertension. Soedamah-Muthu et al. (12) reported no significant association between yogurt consumption (per 50 g/d) and the risk of hypertension (RR: 0.99; 95% CI: 0.96, 1.01; Supplemental Table 10) in their meta-analysis of 5 prospective cohort studies. Results appeared to be consistent between the different studies, and publication bias was not assessed. Data from the prospective CARDIA (Coronary Artery Risk Development in Young Adults) (34) and SUN (Seguimiento University of Navarra)

(40) cohorts are consistent with these findings in showing no significant association between yogurt consumption and hypertension risk (Supplemental Table 11). On the other hand, an inverse association between yogurt consumption and hypertension risk was reported in the Framingham Heart Study (37) (RR: 0.95; 95% CI: 0.90, 0.99). In summary, moderate-quality evidence suggests that yogurt consumption is not associated with the risk of hypertension (Table 2).

Fermented dairy and risk of HTN. Soedamah-Muthu et al. (12) pooled results from 4 prospective cohort studies (Supplemental Table 10) and showed no significant association between the consumption of fermented dairy and the risk of hypertension (RR: 0.99; 95% CI: 0.94, 1.04). The only additional published study on this topic was conducted by Wang et al. (37), who reported an inverse association between the consumption of fermented dairy and the risk of hypertension (Supplemental Table 11). This study has an important weight (n = 2340) relative to data from the meta-analysis by Soedamah-Muthu et al. (12) (n = 7641) and is likely to modify pooled risk estimates. In this context, we suggest that moderate-quality evidence supports a neutral association between the consumption of fermented dairy and the risk of hypertension, with the need for further studies on the topic to yield better quality evidence.

Dairy and risk of hypertension—summary. There is moderate- to high-quality evidence that the consumption of total dairy, low-fat dairy, and milk is associated with a lower risk of hypertension (**Figure 4**, Table 2). There is also moderate- to high-quality evidence that the consumption of high-fat dairy (as per the authors' definition), cheese, yogurt, and fermented dairy is not associated with the risk of hypertension. Although the recommendation to consume low-fat dairy foods in place of regular-fat products is partly consistent with data from blood pressure studies, further investigation is warranted in this area to assess whether the low-fat version of a dairy product (e.g., skimmed milk) is indeed more favorable than its regular-fat version (whole milk) in terms of influencing blood pressure.

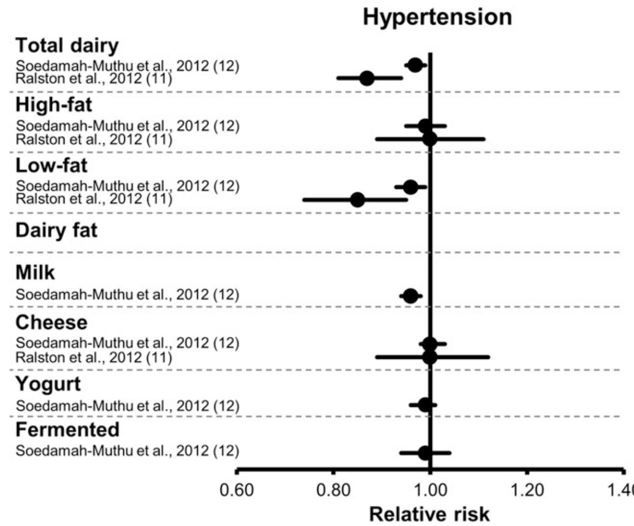

FIGURE 4 Forest plot of RRs from meta-analyses of prospective cohort studies on the association between dairy intake and the risk of hypertension, with their 95% CIs. Each symbol represents data from an individual meta-analysis.

MetS

Two meta-analyses (22, 23) recently examined the association between dairy consumption and the risk of MetS. Analyses were based on data from a total of 9 individual prospective cohort studies, of which 3 used National Cholesterol Education Program–Adult Treatment Panel III MetS criteria (35, 41, 42), 1 study used National Cholesterol Education Program–Adult Treatment Panel III criteria with modified waist circumference thresholds (38), 1 study used the insulin-resistance syndrome criteria (34), 1 study used the American Heart Association criteria (43), 2 studies used the International Diabetes Federation criteria (44, 45), and 1 study used both American Heart Association and International Diabetes Federation criteria (40).

Total dairy and risk of MetS. Chen et al. (22) reported an inverse association between total dairy consumption and the risk of MetS (RR: 0.86; 95% CI: 0.79, 0.92; **Supplemental Table 12**). There was no heterogeneity between studies, and no evidence of publication bias. A dose-response analysis revealed that each daily serving of dairy was associated with a 6% reduction in the risk of MetS (RR: 0.94; 95% CI: 0.90, 0.98). The meta-analysis by Kim and Je (23) also revealed an inverse association between total dairy consumption and the risk of MetS (RR: 0.85; 95% CI: 0.73, 0.98), with no evidence of heterogeneity between studies or publication bias. Similar results were obtained in their dose-response meta-analysis, in which the risk of MetS was reduced by 12%/daily serving of total dairy (RR: 88; 95% CI: 0.82, 0.95). The inclusion of the cohort study by Sayón-Orea et al. (40), which was based on yogurt intake only, appeared to have no impact on the overall results reported by Kim and Je. The meta-analyses by Chen et al. and Kim and Je both received moderate-quality scores. One additional prospective cohort study suggested no significant association between total dairy consumption and the risk of MetS (46), although the risk estimate was similar to the one reported in the meta-analyses (**Supplemental Table 13**).

In summary, data from 2 recent meta-analyses, which were based on almost identical pools of prospective cohort studies, suggest that total dairy consumption is inversely associated with the risk of MetS. Data from 1 additional small prospective cohort study reported a similar association, although it did not reach significance. According to the adapted GRADE criteria, this indicates that the favorable association between total dairy consumption and the risk of MetS is supported by moderate-quality evidence (Table 2).

Dairy fat and risk of MetS. To the best of our knowledge, no meta-analysis has yet evaluated the association between dairy fat and the risk of MetS, and data from available prospective cohort have been inconsistent. Thus, in light of very low-quality evidence, the association between dairy fat and the risk of MetS remains uncertain. A more detailed discussion on this topic is available in the Supplemental Information.

Milk and risk of MetS. On the basis of pooled data from 3 prospective cohort studies, Chen et al. (22) reported an inverse association between milk consumption and the risk of MetS (RR: 0.75; 95% CI: 0.63, 0.89; Supplemental Table 12). There was no heterogeneity between studies, and publication bias was not evaluated specifically in this meta-analysis. Additionally retrieved data from prospective cohort studies showed either an inverse association (46) or no association (46, 47) between milk consumption with various fat contents and MetS risk (Supplemental Table 13).

The assessment of the association between milk consumption and MetS risk is based on data from 1 meta-analysis of only 4 prospective cohort studies (22), whereas data from additionally retrieved prospective cohort studies are mixed. In that context, we suggest that moderate-quality evidence supports a favorable association between milk consumption and the risk of MetS (Table 2). The extent to which skimmed or low-fat milk compared with regular-fat milk shows different associations with the risk of MetS remains unclear and warrants further research.

Cheese and risk of MetS. To our knowledge, the association between cheese consumption and the risk of MetS has not been examined in a meta-analysis, and the limited number of prospective cohort studies on this topic have yielded inconclusive evidence. The quality of evidence relating cheese intake to MetS risk is considered to be very low and thus the association remains uncertain (Table 2). Additional information is provided in the Supplemental Information.

Yogurt and risk of MetS. There is a limited number of prospective cohort studies and no meta-analysis on the association between yogurt consumption and MetS risk. We judge the quality of the evidence relating yogurt intake to the incidence of MetS to be very low, and thus the association remains uncertain. Additional information is available in the Supplemental Information.

Fermented dairy and risk of MetS. To our knowledge, there are currently no available studies on this topic.

Dairy and risk of MetS—summary. Overall, data on the association between dairy intake and risk of MetS are limited (**Figure 5**). Because total dairy and milk intake may be inversely associated with the risk of MetS (moderate-quality evidence), evidence for other dairy foods are much limited and of very low quality (Table 2). Additional prospective cohort studies and meta-analyses are required to shed new light on this topic.

T2D

Total dairy and risk of T2D. In the meta-analysis by Elwood et al. (7), total dairy intake was associated with a significantly reduced risk of T2D (RR: 0.85; 95% CI: 0.75, 0.96; **Supplemental Table 14**). Results from the individual cohort studies were relatively homogeneous, and there was no analysis of potential publication bias. Tong et al. (9) in their meta-analysis also showed that the intake of dairy products was inversely associated with the risk of T2D (RR: 0.86; 95% CI: 0.79, 0.92). There was no heterogeneity between studies, and no evidence of publication bias. Gao et al. (14) reported an inverse association between total dairy intake and the risk of T2D (RR: 0.89; 95% CI: 0.81, 0.98); and in a dose-response analysis, the risk of T2D was reduced by 5% for each 200-g/d increase in total dairy intake (RR: 0.95; 95% CI: 0.92, 0.98). The authors indicated that there was significant heterogeneity between studies in both analyses but no evidence of publication bias. Aune et al. (13) meta-analyzed results from essentially the same pool of prospective cohort studies, with a few exceptions, and reproduced the inverse association between total intake of dairy products and the risk of T2D (RR: 0.89; 95% CI: 0.82, 0.96; RR: 0.93 · 400 $g^{-1} \cdot d^{-1}$; 95% CI: 0.87, 0.99). The authors reported moderate heterogeneity in results from the various cohort studies. Interestingly, the meta-analysis conducted by Chen et al. (16), which was based on the largest sample size (n = 459,770), showed no significant association between the total consumption of dairy products and the risk of T2D (RR: 0.98; 95% CI: 0.96, 1.01). There was significant heterogeneity between studies, but no evidence of publication bias. Finally, the most recent meta-analysis conducted by Gijsbers et al. (25) also reported no association between total dairy consumption and T2D risk (RR: 0.97; 95% CI: 0.95, 1.00). Only 1 additional prospective cohort study was retrieved, and no significant association was reported between total dairy intake and T2D risk (48) (**Supplemental Table 15**).

In sum, results from available meta-analyses are not entirely consistent, showing either favorable (4 meta-analyses) or neutral (2 meta-analyses) associations between dairy intake and the risk of T2D, despite the fact that all were based largely on the same pool of prospective cohort studies. Considering the weight of favorable meta-analyses compared with neutral analyses, we suggest that there is moderate-quality evidence supporting a favorable relation between total dairy intake and incident T2D (Table 2). As emphasized throughout this review, dairy products are heterogeneous, and pooling them into a single analysis may lead to significant heterogeneity, thus providing only partial perspectives on their association with clinical outcomes. This appears to be particularly the case for T2D.

Dairy fat and risk of T2D. Tong et al. (9) showed that the consumption of high-fat dairy foods (as per the authors' definition) was not associated with incident T2D (RR: 1.00; 95% CI: 0.89, 1.10), whereas the consumption of low-fat dairy was associated with a significantly reduced risk of T2D (RR: 0.82; 95% CI: 0.74, 0.90). Data from the Gao et al. (14) meta-analysis are consistent with these findings. Indeed, a reduced risk of T2D was associated with the intake of low-fat dairy (RR: 0.81; 95% CI: 0.74, 0.89) but not with the intake of high-fat dairy (RR: 0.95; 95% CI: 0.85, 1.07). There was no evidence

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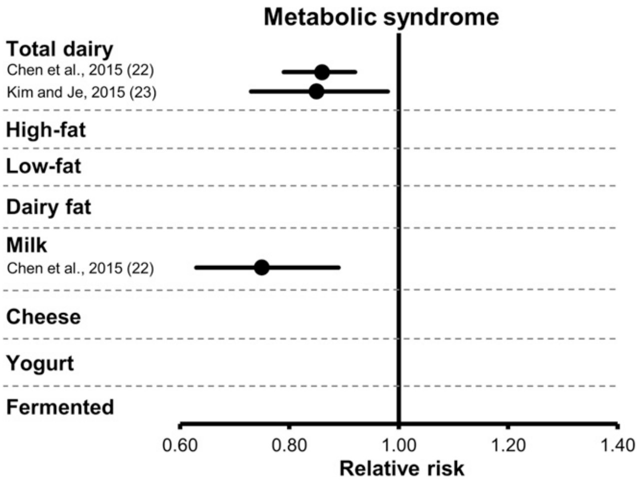

FIGURE 5 Forest plot of RRs from meta-analyses of prospective cohort studies on the association between dairy intake and the risk of metabolic syndrome, with their 95% CIs. Each symbol represents data from an individual meta-analysis.

of heterogeneity between studies. Dose-response analysis of these cohort studies led to similar observations. Aune et al. (13) reported no association between the intake of high-fat dairy and incident T2D (RR: 0.96; 95% CI: 0.87, 1.06) in their meta-analysis, without heterogeneity between studies. On the other hand, a significant inverse association was reported for low-fat dairy intake and the risk of T2D (RR: 0.83; 95% CI: 0.76, 0.90). Again, the dose-response analysis confirmed these results. Recently, Gijsbers et al. (25) reported no association between T2D risk and the consumption of high-fat (RR: 0.97; 95% CI: 0.95, 1.00) or low-fat (RR: 0.98; 95% CI: 0.93, 1.04) dairy. There was significant heterogeneity between individual studies, but no evidence of publication bias. The association between biomarkers of dairy fat and T2D incidence was assessed in the meta-analysis by de Souza et al. (20). In this particular analysis, inverse associations were reported between T2D risk and circulating concentrations of total ruminant TFAs (RR: 0.58; 95% CI: 0.46, 0.74), pentadecanoic acid (RR: 0.64; 95% CI: 0.46, 0.87) and heptadecanoic acid (RR: 0.67; 95% CI: 0.63, 0.71). Of note, these analyses were based on a limited number of prospective cohort studies (from 2 to 5).

In summary, studies that ascertained the association between low-fat dairy consumption and the risk of T2D appear to be relatively consistent, hence providing high-quality evidence to support a favorable association. On the other hand, data from cohort studies of self-reported high-fat dairy intake and from analysis of biomarkers of dairy fat intake are somehow at odds. Thus, we suggest there is moderate-quality data to support the thesis that the consumption of high-fat dairy has neutral effects on the risk of T2D (Table 2). The extent to which further analyses of dairy fat intake with the use of biomarkers, as in the meta-analysis by de Souza et al. (20), will modify this perspective by confirming a favorable association between dairy fat intake and the risk of T2D is of interest in the future.

Milk and risk of T2D. Elwood et al. (6) in their meta-analysis reported an inverse association between milk intake and the risk of T2D (RR: 0.92; 95% CI: 0.86, 0.97; Supplemental Table 14). The intake of whole milk showed no association with the risk of T2D (RR: 0.95; 95% CI: 0.86, 1.05) in the meta-analysis by Tong et al. (9). In the Gao et al. (14) meta-analysis, high compared with low intakes of milk were not significantly associated with a lower risk of T2D (RR: 0.89; 95% CI: 0.78, 1.01). Analyses revealed moderate heterogeneity between studies. A specific analysis based on milk-fat content indicated that the intake of low-fat milk was associated with a significant reduction in the risk of T2D (RR: 0.82; 95% CI: 0.69, 0.97), whereas the intake of whole-fat milk was not (RR: 1.12; 95% CI: 0.99, 1.27) (14). Aune et al. (13) reported no significant association between milk intake and T2D risk (RR: 0.87; 95% CI: 0.70, 1.07) on the basis of data from 7 prospective cohort studies. In the most recent meta-analysis, Gijsbers et al. (25) reported no significant association between total milk intake and T2D risk (RR: 0.97; 95% CI: 0.93, 1.02). Significant heterogeneity was observed, with no evidence of publication bias. The authors reported similar associations with T2D risk for high-fat (whole) milk (RR: 0.99; 95% CI: 0.88, 1.11) and low-fat milk (RR: 1.01; 95% CI: 0.97, 1.05). In 2 additional prospective cohort studies (48, 49), milk consumption was not associated with the risk of T2D (Supplemental Table 15).

In summary, 3 of the 4 available meta-analyses showed that the intake of milk is not associated with a reduced risk of T2D, whereas data from 1 meta-analysis suggested a favorable inverse association between milk intake and T2D risk. The meta-analyses by Gao et al. (14) and Aune et al. (13) are based on very similar pools of studies. Conversely, the meta-analyses by Elwood et al. (6) and by Tong et al. (9), both published before 2013, are based on smaller pools of cohort studies. Considering the quality of the meta-analyses available, their findings, and their similarities, we suggest that there is moderate-quality evidence that indicates that milk intake is not associated with the risk of T2D, because it remains possible that risk estimates will be modified once all prospective cohort studies are combined (Table 2). Further studies differentiating low-fat and regular-fat milk with regard to the risk of T2D are also needed.

Cheese and T2D. According to the meta-analysis by Gao et al. (14), cheese consumption is associated with a reduced risk of T2D (RR: 0.82; 95% CI: 0.77, 0.87; Supplemental Table 14). Their dose-response analysis also revealed a significant inverse association between cheese intake (30 g/d) and incident T2D (RR: 0.80; 95% CI: 0.69, 0.93). There was, however, significant heterogeneity between studies. In the meta-analysis by Aune et al. (13), cheese consumption, when analyzed on a high-compared with low-intake basis (RR: 0.91; 95% CI: 0.84, 0.98) or by using a dose-response approach (RR: 0.92 per increment of 50 g/d; 95% CI: 0.86, 0.99), was also associated with a lower risk of T2D. In their 2016 meta-analysis, Gijsbers et al. (25) did not confirm the inverse association between cheese consumption and T2D risk (RR: 1.00 · 10 $g^{-1} \cdot d^{-1}$; 95% CI: 0.99, 1.02). Significant heterogeneity was present with an increased risk of T2D in men with higher cheese consumption (RR: 1.05 · 10 g^{-1} · d^{-1}; 95% CI: 1.02, 1.09).

Because the available meta-analyses are based on the same pool of prospective cohort studies, because of inconsistencies among meta-analyses, and because of significant heterogeneity between the various individual cohort studies, we suggest that the reduced risk of T2D associated with cheese consumption is supported by moderate-quality evidence (Table 2). More studies are needed to substantiate if low-fat cheese is more favorably associated with T2D risk than regular-fat cheese.

Yogurt and risk of T2D. Tong et al. (9) showed that high compared with low yogurt consumption was associated with a significantly lower risk of T2D (RR: 0.83; 95% CI: 0.74, 0.93). Heterogeneity between studies was not assessed, but there was no evidence of publication bias. In their meta-analysis, Gao et al. (14) also reported that high compared with low intake of yogurt was inversely associated with incident T2D (RR: 0.85; 95% CI: 0.75, 0.97). Analysis of the dose-response association did not quite reach significance (RR: 0.91 · 50 g^{-1} · d^{-1}; 95% CI: 0.82, 1.00). The authors reported significant heterogeneity between studies. Finally, Aune et al. (13) indicated that the intake of yogurt was associated with a significantly reduced risk of T2D (RR: 0.86; 95% CI: 0.75, 0.98), which was not the case in the dose-response analysis (RR: 0.78 · 200 g^{-1} · d^{-1}; 95% CI: 0.60, 1.02). On the basis of an updated meta-analysis of 14 studies, Chen et al. (16) reported a favorable association between yogurt consumption and the risk of T2D (RR: 0.82; 95% CI: 0.70, 0.96). There was significant heterogeneity between studies, but no publication bias. Finally, Gijsbers et al. (25) pooled data from 12 studies and reported an inverse, nonlinear dose-response association between yogurt consumption and T2D risk (RR: 0.94; 95% CI: 0.90, 0.97). In 2 additional prospective cohort studies not included in these meta-analyses, yogurt consumption was also inversely associated with T2D risk (48, 50).

The 5 meta-analyses on the association between yogurt intake and the risk of T2D reported consistent results. Hence, we suggest that there is high-quality evidence that supports an inverse association between the intake of yogurt and the risk of T2D (Table 2). The extent to which low-fat yogurt is more favorable that regular-fat yogurt in influencing the risk of T2D is unknown.

Fermented dairy and risk of T2D. In the meta-analysis by Gao et al. (14), there was no significant association between intakes of fermented dairy products and the risk of T2D (RR: 0.94; 95% CI: 0.75, 1.18). On the other hand, the intake of fermented dairy was associated with a significant reduction in the risk of T2D (RR: 0.88; 95% CI: 0.79, 0.98) in the meta-analysis by Aune et al. (13). Gijsbers et al. (25) reported no association between fermented dairy product consumption and the risk of T2D (RR for low-fat fermented dairy: 0.98; 95% CI: 0.90, 1.06; RR for high-fat fermented dairy: 0.92; 95% CI: 0.83, 1.03). No heterogeneity and no publication were reported. In one additional prospective cohort study (56), total fermented and regular- and high-fat fermented dairy intakes were not associated with the risk of T2D [RR (95% CI): 0.85 (0.68, 1.08) and 1.16 (0.91,1.49), respectively], whereas the consumption of low-fat fermented dairy was associated with a reduced risk of T2D (RR: 0.76; 95% CI: 0.60, 0.99; Supplemental Table 15).

In sum, the consumption of fermented dairy does not appear to be associated with the risk of T2D. This is based on moderate-quality evidence, because the 3 meta-analyses available relied on almost the same pools of prospective cohort studies (Table 2).

Dairy and T2D—summary. There is high-quality evidence that intakes of low-fat dairy and yogurt are associated with a reduced risk of T2D (Table 2, **Figure 6**). There is moderate-quality evidence that suggests that intakes of total dairy and cheese are also associated with a reduced risk of T2D. Finally, the neutral association between intakes of high-fat dairy, milk, and fermented dairy and T2D is supported by evidence of high to moderate quality.

Interpretation and Conclusions

Investigating the impact of food products such as dairy on health is highly challenging. There are obviously no randomized controlled trials with hard endpoints available on this topic, and such a trial is highly unlikely in the future. Thus, the assessment of the association between dairy consumption and clinical outcomes needs to rely primarily on data from observational studies. This review used data from meta-analyses in an attempt to draw the most reliable, evidence-based conclusions relating dairy intake to cardiovascular-related clinical outcomes. Table 2 summarizes the quality of evidence from the adapted GRADE scale as well as the direction of associations between dairy intake in various forms and clinical outcomes, thereby answering the following key nutrition- and health-related questions.

1. Is dairy consumption detrimentally, neutrally, or beneficially associated with the risk of cardiovascular-related clinical outcomes, including MetS and T2D?

First, there is no evidence that the consumption of any form of dairy product is detrimentally associated with the risk of any cardiovascular-related clinical outcome. In fact, high-quality evidence supports favorable associations (i.e., decreased risk) between:

- total dairy intake and the risk of hypertension, and
- low-fat dairy and yogurt intake and the risk of T2D.

On the basis of the adapted GRADE criteria, we are confident that these associations are robust and hence unlikely to be modified by further research.

Moreover, moderate-quality evidence suggests favorable associations between:

- intakes of total dairy, low-fat dairy, cheese, and fermented dairy products and the risk of stroke;
- intakes of low-fat dairy and milk and the risk of hypertension;
- intakes of total dairy and milk and the risk of MetS; and
- intakes of total dairy and cheese and the risk of T2D.

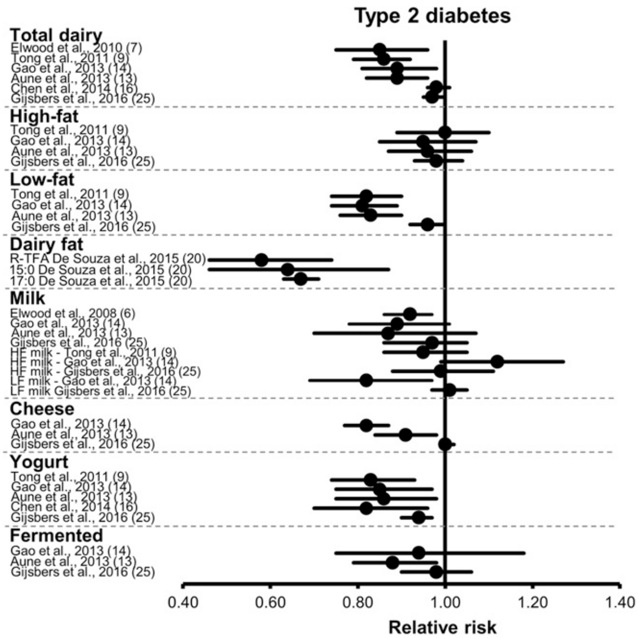

FIGURE 6 Forest plot of RRs from meta-analyses of prospective cohort studies on the association between dairy intake and the risk of type 2 diabetes, with their 95% CIs. Each symbol represents data from an individual meta-analysis. HF, high-fat; LF, low-fat; R-TFA, ruminant *trans* fatty acids.

On the basis of the adapted GRADE criteria, these favorable associations are very likely. However, future studies may modify risk estimates toward confirmed favorable associations or toward the null.

Finally, there is high- to moderate-quality evidence that:

- consumption of total dairy, cheese, and yogurt is neutral in terms of CVD risk;
- consumption of all forms of dairy, except for fermented, is neutral in terms of CAD risk;
- consumption of regular- and high-fat dairy, milk, and yogurt is neutral in terms of stroke risk;
- consumption of regular- and high-fat dairy, cheese, yogurt, and fermented dairy is neutral in terms of risk of hypertension; and
- consumption of regular- and high-fat dairy, milk, and fermented dairy is neutral in terms of risk T2D.

2. Is the recommendation to consume low-fat as opposed to regular- and high-fat dairy supported by the existing evidence?

First, there is no evidence from this extensive review that the consumption of dairy fat or of regular- and high-fat dairy is detrimental to cardiovascular-related clinical outcomes. More specifically, the:

- consumption of regular- and high-fat dairy is neutral in terms of risk of CAD, stroke, hypertension, and T2D, which is supported by high- to moderate-quality evidence;
- consumption of low-fat dairy is neutral in terms of CAD risk, which is supported by high-quality evidence; and
- consumption of low-fat dairy is favorably associated with the risk of stroke, hypertension, and T2D, which is supported by high- to moderate-quality evidence.

Examining the association of dairy intake to health according to fat content is tremendously challenging for several reasons. In most epidemiologic studies, the "low-fat" terminology generally referred to fat-reduced products such as skimmed or low-fat milk (0–1% fat), nonfat yogurt (0% fat), and low-fat cheese (15–20% fat). Inversely, whole milk (3% fat) has been analyzed in population studies along with regular-fat cheese (>30% fat) as regular- and high-fat dairy products. The fat and nutrient profile is highly variable within each of those categories. Grouping them into simplistic classes such as regular- and high-fat or low-fat may confound the analysis of their association with clinical outcomes. A good example of this pertains to cheese, which even in its low-fat version is a product that is much higher in fat, and thus that contributes more to SFA intake, than whole-fat milk. Cheese intake is inversely associated with the risk of stroke and T2D (supported by moderate-quality evidence), whereas the intake of regular-fat dairy shows a neutral association with these outcomes (moderate- to high-quality evidence). The use of biomarkers of dairy fat intake provides a certain perspective on the association between regular- and high-fat dairy and health. However, it is limited by the fact that it does not allow the study of the association between whole foods and health.

It is unclear in dietary guidelines if the recommendations to consume low-fat dairy imply that individuals select the low-fat version in place of the regular- and high-fat version of a dairy product or choose an intrinsically low-fat dairy (e.g., skimmed milk) instead of intrinsically high-fat dairy (e.g., cheese). The first scenario represents a key research gap that needs proper research. Indeed, high- or moderate-quality evidence that shows that low-fat milk compared with whole-milk or low-fat cheese compared with regular-fat cheese is better for health is utterly lacking. The consumption of low-fat dairy may provide some advantages with respect to the risk of stroke, hypertension, and T2D, but there are currently no data indicating that this is the case for each dairy product taken individually. For the second scenario (e.g., choosing skimmed milk instead of cheese), again, the evidence is weak because in some instances (e.g., stroke, T2D), cheese consumption is actually associated with a reduced risk. Replacing a solid dairy such as cheese with a liquid dairy such as milk is a much more complex dietary change than switching between 2 liquid foods or between 2 solid foods. Thus, more research that addresses this particular scenario is also warranted, not just from a health perspective but also from a dietary change perspective. In the meantime, we hypothesize that the recommendation to focus on low-fat in place of regular- and high-fat dairy products is a concept that may be not be fully captured by the population, that such a concept may not reflect food choices that people make at the individual level, and that such a recommendation is not based on the current state of evidence.

As indicated above, additional studies are needed to address the following key research gaps:

- to compare the impact of regular-fat dairy products with their reduced-fat or skimmed versions on health outcomes;

- to assess the association between milk and fermented dairy and the risk of CVD specifically, because these associations are currently uncertain;
- to assess the association between cheese, yogurt, and fermented dairy intakes specifically and the risk of MetS specifically, because these associations are currently uncertain; and
- to conduct higher quality meta-analyses, because 18 of the 21 available to date (Table 1) have been scored as being of moderate quality or lower on the basis of the recognized MOOSE grading system.

Assessing publication bias systematically in future meta-analyses will also greatly enhance the quality of evidence. This is identified as a major shortcoming in the existing literature.

Some of the meta-analyses presented in this review have revealed heterogeneity between prospective cohort studies. Most studies have adjusted risk estimates for various covariables, limiting the risk of confounding. However, one cannot exclude the possibility of uncontrollable bias in large, prospective, epidemiologic cohort studies. Kratz et al. (51) stressed that dietary assessment that uses FFQ in prospective cohort studies may be influenced by the social value associated with the food. In Western countries, high-fat dairy consumption is much less prevalent than low-fat dairy consumption. This has an obvious impact on the statistical power to measure associations with high-fat dairy. Kratz et al. also discussed the impact of differences in bovine feeding practices between countries, which affect the quality and composition of the dairy fat. This has not been taken into account in existing prospective cohort studies. Finally, the extent to which the association between dairy intake and health outcomes is fully independent of concurrent variations in other health-related variables, such as diet, socioeconomic status, and other factors, is unclear (51). Additional studies are therefore also needed to assess the association between dairy intake and clinical outcomes in various populations (obese compared with non-obese, males compared with females, different geographical areas) (16, 51).

In conclusion, this systematic review provides an in-depth perspective on the association between dairy product consumption and the risk of cardiovascular-related clinical outcomes, including MetS and T2D. Although there are still key research gaps to address, evidence suggests either a neutral or a favorable association between dairy intake and cardiovascular-related outcomes. These data are consistent with current dietary guidelines, which place dairy as one of the pillars of healthy eating. However, the review also emphasized that the recommendation to focus on low-fat in place of regular- and high-fat dairy is currently not evidence-based. Further research is needed to specifically address this key research gap.

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All authors read and approved the final manuscript.

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Consumption and Sources of Saturated Fatty Acids According to the 2019 Canada Food Guide: Data from the 2015 Canadian Community Health Survey

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Abstract: The 2019 revised version of Canada's Food Guide (CFG) recommends limiting the consumption of processed foods that are high in saturated fatty acids (SFA). Yet, the contributions of each CFG group to the total SFA intake of Canadians are not specifically known. The objectives of this study were to quantify the total SFA intake of Canadians, determine the sources of SFA consumed by Canadian adults, and identify potential differences in these sources. A nation representative sample from the Canadian Community Health Survey (CCHS – Nutrition 2015) was used for these analyses. Dietary intakes were measured using a single 24-h recall. Food sources of SFA were classified according to the revised 2019 CFG categories. We have also examined the contribution of foods not included in these three categories to total SFA intake. Among Canadian adults, total SFA contributed to 10.4 ± 0.1% (SE) of total energy intake (E). The "Protein foods" (47.7 ± 0.5% with 23.2 ± 0.4% from *milk and alternatives* and 24.5 ± 0.4% from *meats and alternatives*) and "All other foods" (44.2 ± 0.5%) categories were the main sources of total SFA intake. Few differences in SFA sources were identified between sexes, age groups, education levels, and body mass index (BMI) categories. These data show that the mean SFA consumption is greater than the 10% E cut-off previously proposed in Canada. Future studies should examine which food substitution is most likely to contribute to a greater reduction in SFA intake at the population level.

Keywords: Canada; Canadian adults; Canada's Food Guide; CCHS 2015; saturated fats

1. Introduction

Dietary saturated fatty acids (SFA) increase low-density lipoprotein (LDL) cholesterol (LDL-C) when compared with carbohydrates and polyunsaturated fats [1]. Accordingly, the replacement of SFA by polyunsaturated fats reduces the risk of cardiovascular diseases (CVD) [1,2]. However, many studies emphasize that the association between SFA and CVD risk may depend on its dietary source [3–5]. For example, the intake of SFA from dairy products such as cheese and milk showed no association with the risk of CVD, while the intake of SFA from meats was positively associated with the risk of CVD [4,5]. Nonetheless, the 2019 revised version of Canada's Food Guide (CFG) recommends limited intakes of all foods high in SFA, sodium, and sugars [6]. Additionally, Canada's dietary guidelines recommend that foods containing mostly unsaturated fatty acids replace foods that contain mostly SFA, irrespective of the food source [6]. Since SFA is a nutrient of public health interest, it is important to quantify SFA intake in Canada and identify the predominant food sources of SFA within the new CFG 2019 categories in the Canadian diet, which are currently unknown.

Therefore, the objectives of this study were to quantify the SFA intakes of Canadian adults, determine the sources of SFA consumed by Canadian adults, and identify how these vary according to various sociodemographic characteristics and body weight status. We hypothesized that the mean SFA intake of Canadian adults is above current recommendations, and that foods not included in any of the three new CFG categories are the most important contributors to SFA consumption in Canadian adults. We also hypothesized that men consume more SFA from protein foods than women, that body weight is positively associated with total SFA intake, and that age is inversely associated with the proportion of SFA from foods not included in the CFG categories.

2. Materials and Methods

2.1. Study Population

Data from the nutrition component of the 2015 Canadian Community Health Survey (CCHS Nutrition) was used for this study. The CCHS Nutrition is a sample survey with a cross-sectional design providing information on the eating habits and dietary intakes of Canadians aged 1 year old and over living in the 10 Canadian provinces. People living on reserves and other Aboriginal settlements, full-time members of the Canadian Forces, and institutionalized individuals were excluded from the survey's coverage. The sampling method, based on age, sex, geography, and socioeconomic status was designed in order to generate a sample representative of the Canadian population. For the present analyses, only Canadian adults were included (i.e., individuals of <19 years or >70 years were excluded). Weight status was qualified according to body mass index (BMI). The present study objectives were pre-specified in contract #17-SSH-LAVAL-5405 with Statistics Canada.

2.2. Dietary Data Collection

Dietary data were obtained using a single computer-assisted 24-h recall administered by trained interviewers using the Automated Multiple-Pass Method (AMPM) [7]. The AMPM consists of five steps: a quick list of foods easily remembered by the respondent, a list of nine categories of foods often forgotten by respondents (e.g., beverages, sweets, and snacks), time and occasion of consumption of foods consumed at the same time, details on each food consumed and where it was consumed, and a final probe to make sure no foods were forgotten [7]. Energy and nutrient intakes were derived from the Canadian Nutrient File (CNF—2015 version). The CNF was representative of foods available on the market at the time of the survey [8].

SFA food sources were classified according to the new 2019 CFG categories: (1) vegetables and fruits (excluding fruit and/or vegetable juices), (2) whole grain foods (excluding refined grains), and (3) protein foods, which include the previous CFG categories *meats and alternatives* and *milk and alternatives*. The contribution to total SFA intake of "All other foods", i.e., all foods not included in the three new food categories of the CFG such as fruit juices, refined grains, and salty snacks, was also examined.

2.3. Statistical Analyses

All the analyses were undertaken using survey-specific procedures to account for the CCHS Nutrition design and balanced repeated replication (BRR) for variance estimation. The sampling weights and 500 bootstrap weights provided by Statistics Canada were used to achieve the representativeness of the study sample. Thus, the results presented here are representative of the entire adult Canadian population aged 19 to 70 years with exclusion of the aforementioned groups. Means, medians, and variances of continuous variables were obtained using PROC SURVEYMEANS. Proportions/variances of categorical variables were computed using PROC SURVEYFREQ. Potential differences among sociodemographic characteristics and weight statuses were assessed using general linear models in PROC SURVEYREG with Tukey–Kramer adjustment for multiple comparisons when appropriate. SAS (v. 9.4) was used for all the analyses. *p*-values lower than 0.05 were considered statistically significant.

3. Results

3.1. CCHS Sample

The mean age (±SE) of the sample used for analyses was 45.0 ± 0.3 years, with 50.2% of respondents being female and 48.3% having a household income greater than $80,000/year. The sample was evenly distributed among education levels, with 33.9% having a high school diploma or no diploma, 31.0% having a CEGEP, college, or trade school certificate, and 34.4% with a University degree. CEGEP is a pre-university and technical college institution that is specific to the Province of Quebec. Over one-third (39.3%) of Canadian adults were in the normal weight category (BMI <25 kg/m^2), 34.1% were overweight (BMI 25–30 kg/m^2), and 26.6% were obese (BMI >30 kg/m^2).

3.2. Saturated Fatty Acids Consumption

SFA contributed to 10.4% of total energy intake (E) among Canadian adults in 2015 (Table 1). No difference was found between sexes and age groups. Compared with normal-weight individuals, adults with obesity consumed slightly more SFA (+0.6%E, $p = 0.05$). Canadians with a CEGEP, college, or trade certificate consumed more SFA than Canadians with a high school diploma or no diploma, or with a University degree (10.8% E versus 10.2% E and 10.2% E, respectively; $p = 0.005$ and $p = 0.003$, respectively). There were only small differences in total SFA consumption among the 10 Canadian provinces (Table 1).

Table 1. Saturated fatty acids (SFA) consumption in all Canadian adults and according to sex, age group, education level, body mass index, and province of residence.

	% of Total Energy Intake ‡	95% CI		*p*-value *
Canadian adults	10.4	10.2	10.5	–
Sex				0.49
Women	10.4	10.2	10.6	
Men	10.3	10.1	10.5	
Age				0.05
19–30 years	10.6	10.2	10.9	
31–50 years	10.5	10.2	10.7	
51–70 years	10.2	10.0	10.4	
Body mass index				0.07
Normal	10.3	10.0	10.5	
Overweight	10.4	10.1	10.7	
Obesity	10.8	10.4	11.2	
Education level				0.002
High School/No diploma	10.2 [a]	10.0	10.4	
CEGEP †/Trade certificate/college	10.8 [b]	10.6	11.1	
University	10.2 [a]	9.9	10.4	
Unknown	9.3 [a,b]	7.6	11.1	
Province of residence				<0.0001
Newfoundland & Labrador	10.1	9.7	10.5	
Prince Edward Island	11.0	10.6	11.4	
Nova Scotia	10.9	10.5	11.3	
New Brunswick	10.8	10.2	11.3	
Quebec	10.6	10.2	11.0	
Ontario	10.2	10.0	10.5	
Manitoba	10.7	10.2	11.2	
Saskatchewan	10.5	9.9	11.1	
Alberta	10.6	10.2	11.0	
British Columbia	10.0	9.7	10.4	

* *p*-values were found using a linear regression model with Tukey–Kramer adjustment for multiple comparisons. CI: confidence intervals. † CEGEP is a pre-university and technical college institution. specific to the Province of Quebec. ‡ Subgroups without a common superscript letter are significantly different ($p < 0.05$, Tukey–Kramer).

Figure 1 shows the relative contribution of each 2019 CFG category to total SFA intake. We also examined the relative contribution of the former CFG categories, *milk and alternatives* and *meats and alternatives*, to total SFA intake. "Protein foods" (47.8% of total SFA intake) and "All other foods" (44.2% of total SFA intake) were the main sources of SFA in the diet of Canadian adults in 2015. *Milk and alternatives* and *meats and alternatives* equally contributed to SFA from the "Protein foods" category. Whole grain foods were the least important contributor to total SFA intake (2.5% of total SFA intake).

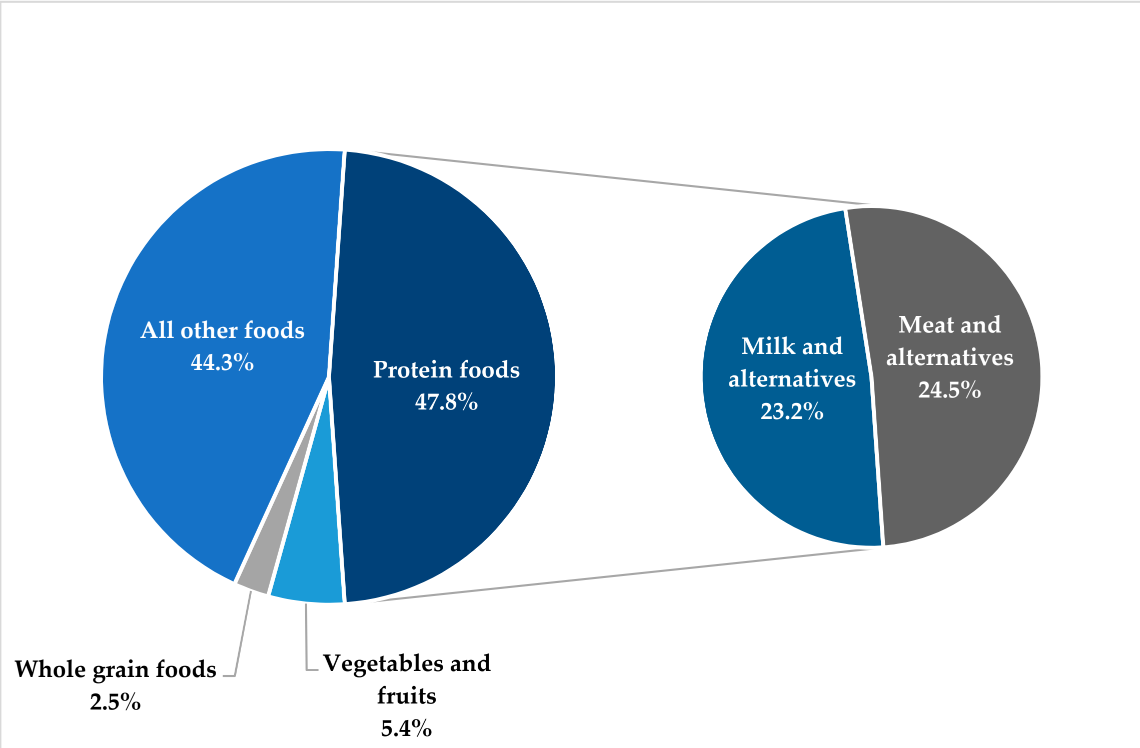

Figure 1. Contribution of 2019 Canada's Food Guide categories to total SFA intake (in % of total SFA intake).

Table 2 shows the relative contribution of each 2019 CFG category to total SFA intake according to sex, age, BMI, and education level. Men consumed more SFA from the "Protein foods" category (49.5% of total SFA intake) and less from the "All other foods" category (42.8% of total SFA intake) than women (46.0% and 45.7% of total SFA intake, respectively). Additionally, men consumed more SFA from *meats and alternatives* than women (+4.3% of total SFA intake, $p < 0.001$). No differences were found between age groups for the "Protein foods" category. However, younger adults (19–30 years old) consumed more SFA from *milk and alternatives* and less from *meats and alternatives* than older adults (31–50 years old and 51–70 years old). Inversely, older adults (51–70 years old) consumed more SFA from whole grain foods than younger adults (19–30 years old). We also found that Canadians with a CEGEP, college, or trade certificate consumed less SFA from whole grain foods than Canadians with a high school diploma or no diploma, or Canadians with a University degree (Table 2). Finally, no difference in SFA sources was identified among BMI categories. Figure 2 presents the proportion of total SFA intake from the "Protein foods" and "All other foods" categories. Respondents living in the province of Quebec consumed more SFA from the "Protein foods" category than respondents living in Newfoundland and Labrador and Manitoba (+6.1% of total SFA intake, both $p < 0.05$). Respondents living in Newfoundland and Labrador and in Prince Edward Island had a higher proportion of their SFA coming from the "All other foods" category than Canadians from Quebec, Ontario, and British Columbia (Figure 2).

Table 2. Contribution of each 2019 Canada's Food Guide categories to total SFA intake according to sex, age, body mass index (BMI), and education level in Canadian adults (19–70 years old).

	Vegetables and Fruits *	Whole Grain Foods	Protein Foods (All)	Milk and Alternatives	Meats and Alternatives	All Other Foods
Sex						
Women	5.6 (5.2–6.0)	2.7 (2.4–3.0)	46.0 (44.8–47.1) [a]	23.6 (22.6–24.6)	22.4 (21.4–23.3) [a]	45.7 (44.5–46.9) [a]
Men	5.2 (4.8–5.6)	2.4 (2.1–2.6)	49.5 (48.0–50.9) [b]	22.7 (21.6–23.9)	26.7 (25.5–28.0) [b]	42.8 (41.4–44.1) [b]
Age						
19–30 years	5.0 (4.4–5.7)	2.1 (1.7–2.6) [a]	48.3 (46.1–50.4)	26.4 (24.3–28.6) [a]	21.8 (20.1–23.6) [a]	44.5 (42.3–46.7)
31–50 years	5.6 (5.1–6.1)	2.5 (2.1–2.8) [a,b]	47.9 (46.5–49.4)	22.8 (21.6–24.0) [b]	25.2 (23.9–26.4) [b]	43.9 (42.4–45.4)
51–70 years	5.3 (4.9–5.7)	2.8 (2.4–3.2) [b]	47.1 (45.9–48.4)	22.0 (20.9–23.1) [b]	25.2 (24.0–26.3) [b]	44.4 (43.2–45.7)
BMI						
Normal (<25 kg/m^2)	5.1 (4.5–5.7)	2.8 (2.3–3.2)	46.3 (44.4–48.3)	27.7 (21.1–24.4)	23.6 (22.1–25.0)	45.7 (43.8–47.7)
Overweight (25–30 kg/m^2)	5.2 (4.7–5.7)	2.5 (2.0–3.0)	48.7 (46.9–50.5)	23.9 (22.4–25.4)	24.8 (22.9–26.7)	43.6 (41.9–45.3)
Obesity (≥30 kg/m^2)	5.8 (5.1–6.5)	2.2 (1.7–2.6)	46.9 (44.7–49.0)	22.2 (20.5–23.9)	24.7 (23.0–26.4)	45.1 (42.9–47.3)
Education level						
High School/No diploma	4.8 (4.4–5.3)	2.6 (2.2–2.9) [a]	47.0 (45.6–48.4)	22.5 (21.2–23.7)	24.5 (23.2–25.9)	45.5 (44.0–47.0)
CEGEP †/Trade certificate/College	5.6 (5.0–6.1)	1.8 (1.6–2.1) [b]	48.7 (47.0–50.4)	23.6 (22.2–25.1)	25.1 (23.8–26.4)	43.8 (42.1–45.5)
University	5.7 (5.2–6.3)	3.2 (2.7–3.6) [a]	47.6 (46.0–49.2)	23.6 (22.2–24.9)	24.1 (22.6–25.5)	43.4 (41.8–44.9)
Unknown	7.2 (3.7–1.1)	1.4 (0.7–2.1) [b,c]	44.0 (36.3–51.8)	18.2 (11.1–25.3)	25.8 (19.7–31.9)	47.4 (38.7–56.1)

Values are presented as mean percentage of total SFA intake (95% CI). * Subgroups without a common superscript letter are significantly different ($p < 0.05$, Tukey–Kramer). † CEGEP is a pre-university and technical college institution specific to the Province of Quebec.

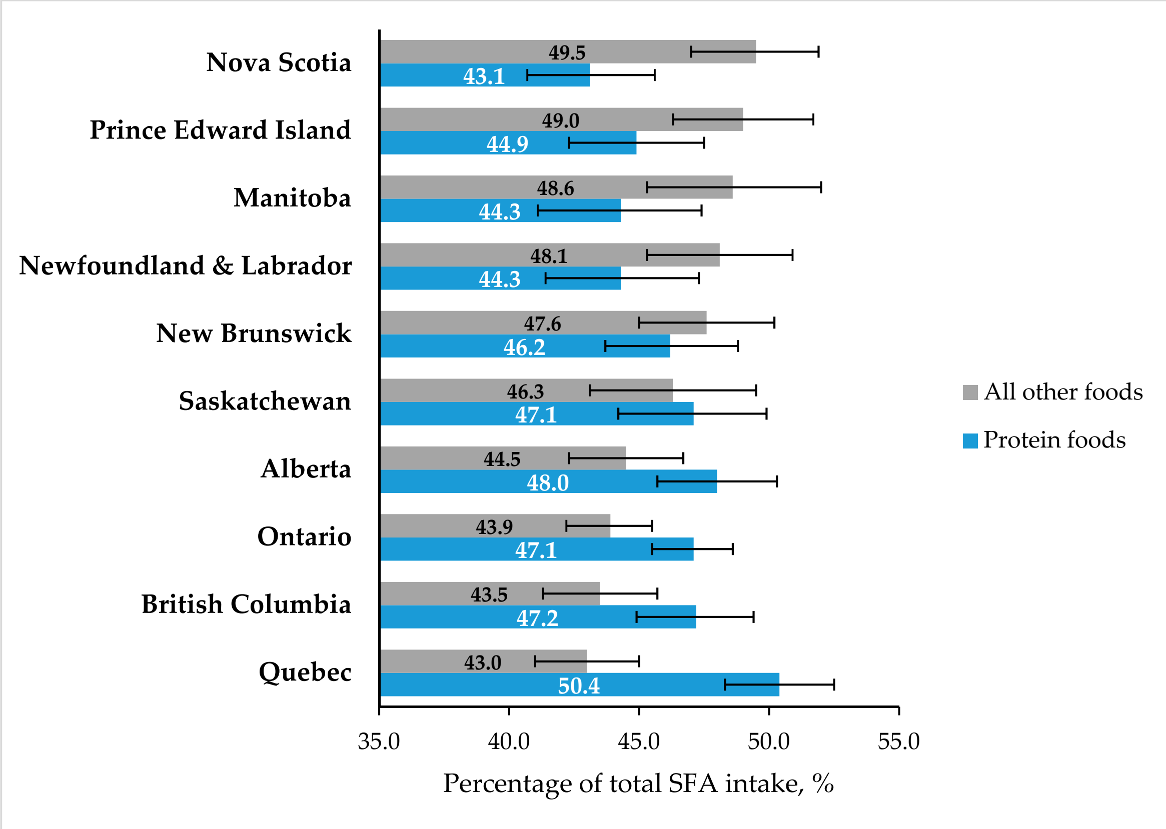

Figure 2. Proportion of total SFA intake from the "All other foods" and "Protein foods" categories, according to province of residence.

4. Discussion

Increased consumption of SFA is known to raise LDL-C, which is an established risk factor of CVD, making it a target nutrient for public health policies [1]. However, data suggest that the association between SFA consumption and CVD risk may vary according to the dietary source of SFA [4,5]. Therefore, it is important from a public health perspective to identify the sources of SFA consumed at a population level to best inform future public health initiatives on healthy eating. In the present study, we have assessed the proportion of total energy intake consumed as SFA by Canadian adults as well as the main sources of SFA in the Canadian diet, based, for the first time, on the revised CFG categories. We found that in 2015, Canadian adults consumed on average slightly more than 10% E as SFA. Moreover, "Protein foods" and "All other foods" were the main categories contributing to total SFA consumption in adults from Canada. Few differences in SFA sources were identified between sexes, age groups, education levels, and weight statuses.

4.1. Saturated Fatty Acids Consumption in Canadian Adults

The World Health Organization (WHO) currently recommends limiting the intake of SFA at a maximum of 10% E per day [9]. Here, we found that in 2015, Canadian adults consumed 10.4% E as SFA, which is slightly higher on average than this recommendation. In Canada, Gray-Donald et al. (2000) documented, using data from the Food Habits of Canadians survey (1997–1998), that the mean SFA intake of adults varied between 9.5–10.2% E, according to sex and age [10]. Health Canada reported a mean SFA intake between 10.0–10.5% E among Canadian adults, depending on sex and age, based on consumption data collected in 2004 as part of cycle 2.2 of the CCHS [11]. This suggests that despite years of public health initiatives aimed at improving diet quality and reducing SFA intake in Canada, SFA intake has apparently remained stable over the last 20 years.

Multiple studies have observed intakes higher than the WHO recommendation at a population level. For example, Huth et al. (2013) found that Americans aged 2 years or older consume a mean of 11.4% E as SFA [12]. Among European countries, Eilander et al. (2015) found that SFA intake varied between 8.9–15.5%E, most countries having a mean consumption above recommendations [13]. Nevertheless, in 2010, the global mean consumption of SFA represented 9.4% E, suggesting that some countries successfully reached intakes below the recommended threshold [14]. It is important to stress that most studies cited above included children, adults, and the elderly, while only adults were considered here.

Data from the present study suggest a weak association between education level and SFA intake ($p = 0.002$); respondents with a CEGEP, college, or trade certificate consumed more SFA than respondents with a lower education (high school diploma or no diploma) or a higher education (University degree). This "non-linear" association between SFA intake and education level is unclear. Also, very few studies have examined the potential associations between SFA consumption and education level, making comparison difficult. However, Hiza et al. (2012) found that American adults with no diploma had higher Healthy Eating Index (HEI) subscores for SFA than those with a higher education level, reflecting a lower intake [15]. Therefore, more studies are needed to better understand how education relates to SFA intake specifically, and whether it is important from a public health perspective or not.

No difference in total SFA intake, which is reported relative to total energy intake, was identified between sexes and age groups in the present study, which is consistent with the available literature on the subject [14–16]. Total SFA intake was also similar across all 10 Canadian provinces. Finally, data suggest that adults with obesity consume slightly more SFA than adults with a normal BMI (+0.6% E, $p = 0.05$), which is consistent with previous data in the American adult population and in the Canadian population [17,18]. However, Raatz et al. analyzed total SFA intake in grams per day, while we used percentage of total energy intake (% E). When looking at total SFA consumption in grams per day in Canadian adults, intakes across all the weight statuses were similar (not shown). We cannot exclude the possibility that other lifestyle-related factors, such as physical activity, smoking, and stress, among others, have influenced this association between SFA intake and obesity. However, it is important to stress that even if some differences in total SFA intake were identified between the studied sociodemographic characteristics, the mean intake of SFA was above the recommended 10% E for all the studied subgroups.

4.2. Contribution of 2019 CFG Food Categories to Total Saturated Fatty Acids Intake

As expected, "Protein foods" (47.8%), and "All other foods" not included in the 2019 CFG (44.2%) were the two main sources of SFA in the diet of Canadian adults in 2015. To our knowledge, this is the first study to evaluate the contribution of each 2019 CFG category to total SFA intake, since most studies available to date have reported data using more specific dietary sources of SFA such as milk, cheese, or red meat. While comparison with data from previous studies is limited by our use of this novel classification of food groups, data are nevertheless consistent with results from studies available on the subject [12,13,19]. For example, Huth et al. found that cheese was the main SFA source in the American diet, followed by beef, milk, and fats and oils other than margarine or butter [12]. In the United Kingdom, fats and oils (19%) were the main source of SFA consumed in the household, followed by meats and meat products (15%), milk and cream (14%), and cheese (10%) [19].

Very few studies have documented the associations between food sources of SFA and sociodemographic characteristics. Kirkpatrick et al. (2019) have shown, based on data from the CCHS Nutrition 2015, that the main singular food sources of SFA in the Canadian diet were red meat mixed dishes, unflavored milk, cheese, egg dishes, and dairy-based desserts [20]. They reported that the top food sources of SFA in Canada were similar across all income groups [20]. They also found that milk was among the top five sources of SFA in all age–sex groups in Canadians aged 2 years of more [20]. Results were not reported according to education levels and BMI categories or according to the new food categories of the 2019 CFG. Additionally, while Kirkpatrick et al. looked at age–sex groups, we looked at age and sex separately, and found that relatively speaking, men consume more SFA from protein foods than women, mostly due to a higher proportion of SFA from the *meats and alternatives* category (+4.3% of total SFA intake versus women, $p < 0.001$).

When looking at potential differences in SFA sources between age groups, we found that younger adults (19–30 years old) consumed less SFA from *meats and alternatives* and more from *milk and alternatives* than older adults (31–50 and 51–70 years old, all $p < 0.05$). This can be due to either a lower consumption of meat or consumption of meat with a lower fat content among younger adults in Canada. A lower consumption of meat among younger adults is unlikely, based on findings by Tugault-Lafleur and Black (2019) [21]. Indeed, Tugault-Lafleur and Black found that the consumption of *meats and alternatives* has increased by 0.3 servings/day in Canadian adults 18–54 years old between 2004–2015 [21]. However, they also reported that the consumption of meat and poultry, fish and shellfish, and processed meats did not change between 2004–2015 in adults 18–54 years old, suggesting that the increase in the consumption of *meats and alternatives* is not due to the consumption of meat *per se* [21]. Additionally, these data were based only on adults aged between 18–54 years. Therefore, the extent to which meat consumption has changed between 2004–2015 among older adults in Canada is unknown. Nevertheless, Daniel et al. have shown, based on NHANES 2003–2004 data, that meat intake declines with age in American adults [22].

Finally, the proportion of SFA from each 2019 CFG category was similar across all BMI categories. This result was unexpected, considering that obese individuals generally report consuming more foods that have a low nutritive value than non-obese individuals [23]. It is possible that the absence of difference in food sources of SFA among BMI categories is due, at least partly, to the well-documented under-reporting of lower nutritive value foods by obese individuals [24,25]. Data from the present study also showed geographical differences among provinces in the proportion of SFA coming from the "Protein foods" and "All other foods" categories. This suggests that public health initiatives aimed at lowering total SFA consumption may need to be developed according to regional differences and specificities.

4.3. Strengths and Limitations

To our knowledge, this is the first study to assess SFA dietary sources using the new 2019 CFG food categories. The assessment of potential differences in SFA intakes and dietary sources between sexes, age groups, education levels, and weight statuses is also a strength, as few studies are currently available on the subject. The use of survey-specific procedures applied to data from CCHS 2015 implies that results are representative of all Canadian adults, which is an important strength. Dietary data was obtained using a 24-h recall, which is affected by within-person variation, mostly caused by the day-to-day variation of food intakes [26]. As a result, a single 24-h recall is not reflective of a given respondent's usual intakes. Regardless, a single 24-h recall can be reflective of the usual intakes at a population level, which made it suitable for the current analyses [26]. Furthermore, there is documented under-reporting in CCHS 2015, suggesting that the true intake of SFA among Canadians may be higher than what was found here [27].

5. Conclusions

These findings suggest that dietary intake of SFA among Canadian adults in 2015 was in average above the 10% E recommendation. Similar results from previous surveys in Canada also suggest that SFA intake has not changed significantly over the past years, despite public health efforts aimed at improving the diet quality of Canadians. Unsurprisingly, almost half of SFA consumed by Canadians in 2015 came from foods that are not recommended and/or not included in the CFG. Therefore, even if the main sources of total SFA intake are protein foods, future health policies should focus primarily on reducing the population's intake of processed foods and/or foods not included in the CFG, as they are an important source of SFA. Such focus on low nutritive quality foods are entirely in line with Canada's most recent dietary guidelines, in which a reduction in the intake of processed foods high in sodium, sugar, and SFA is strongly recommended. Future studies should examine which food substitutions are likely to contribute the most to the reduction of SFA consumption in Canada.

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Notes

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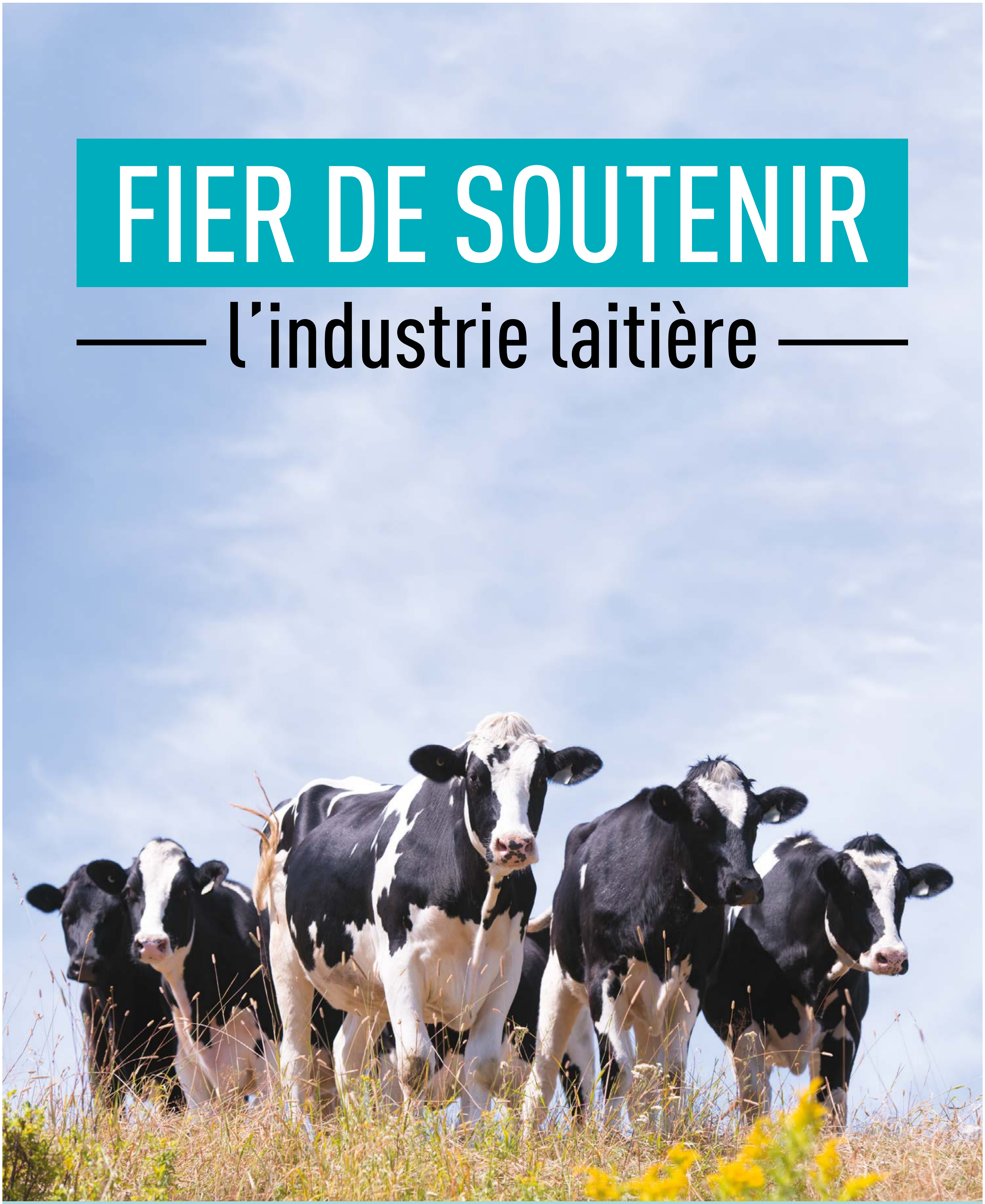

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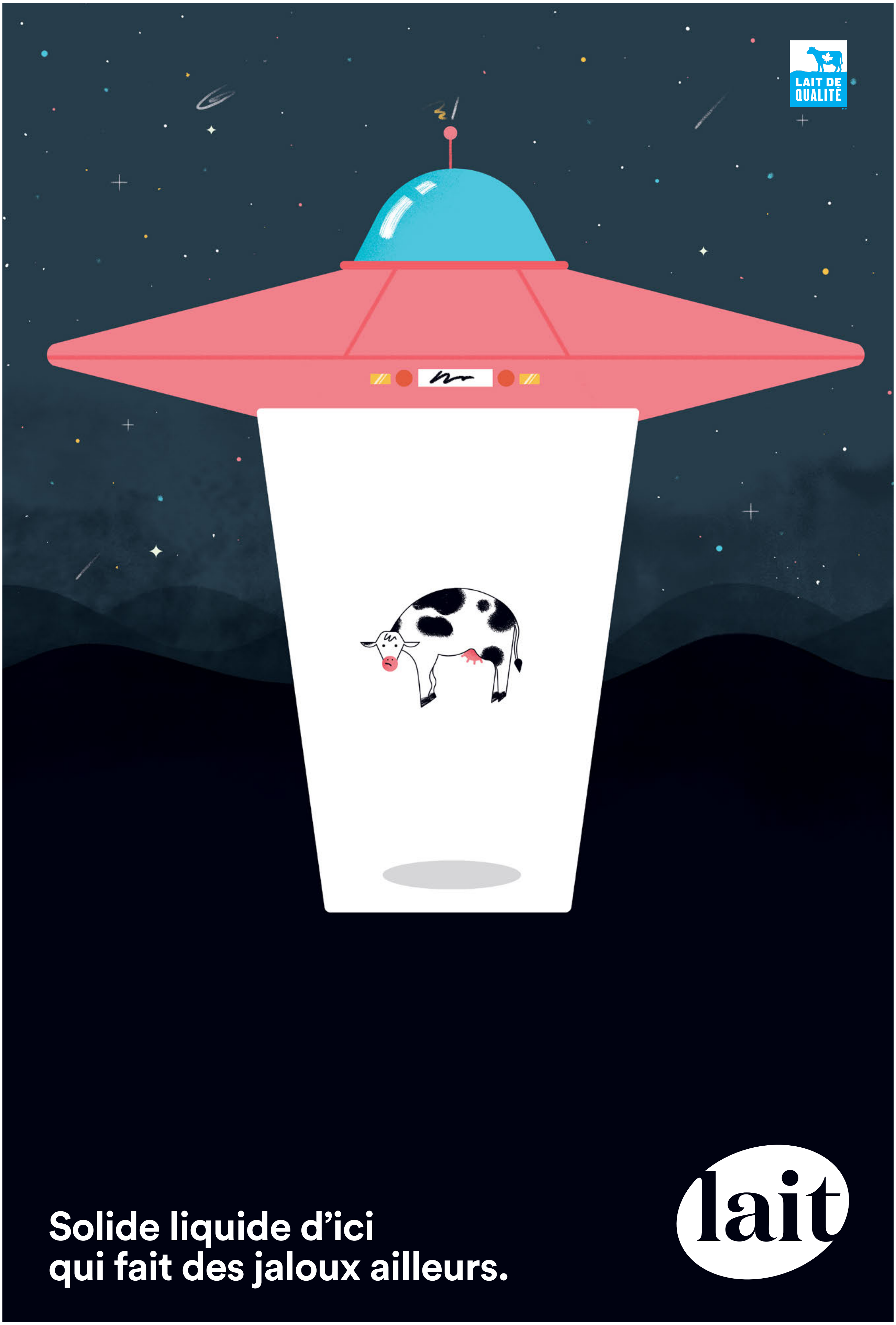
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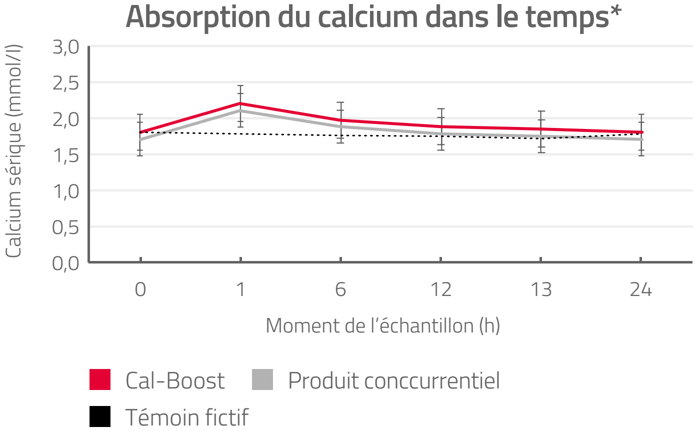

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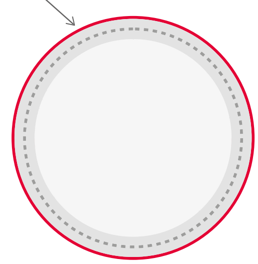

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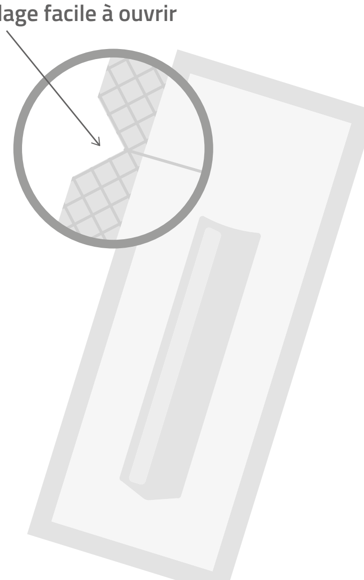

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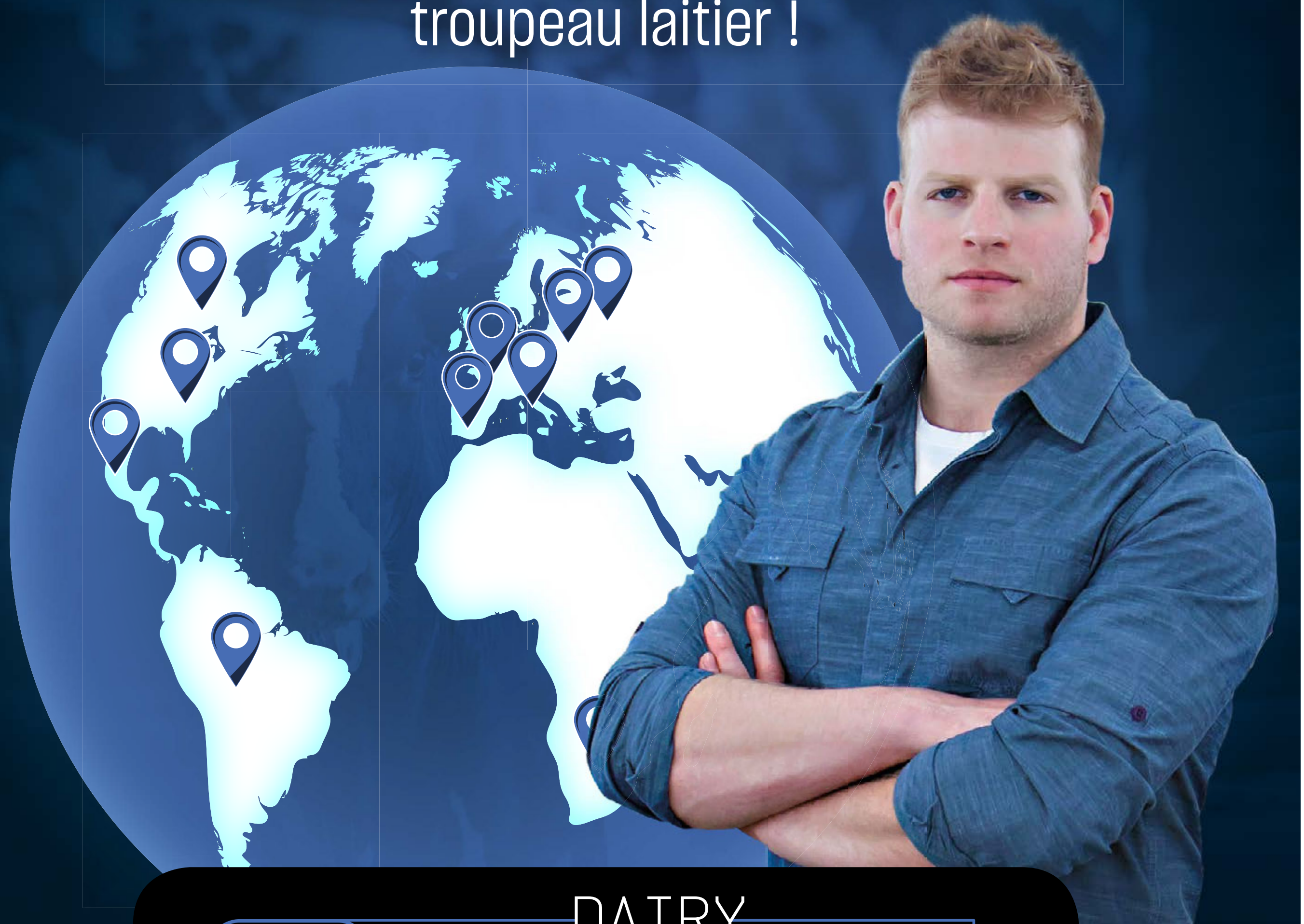

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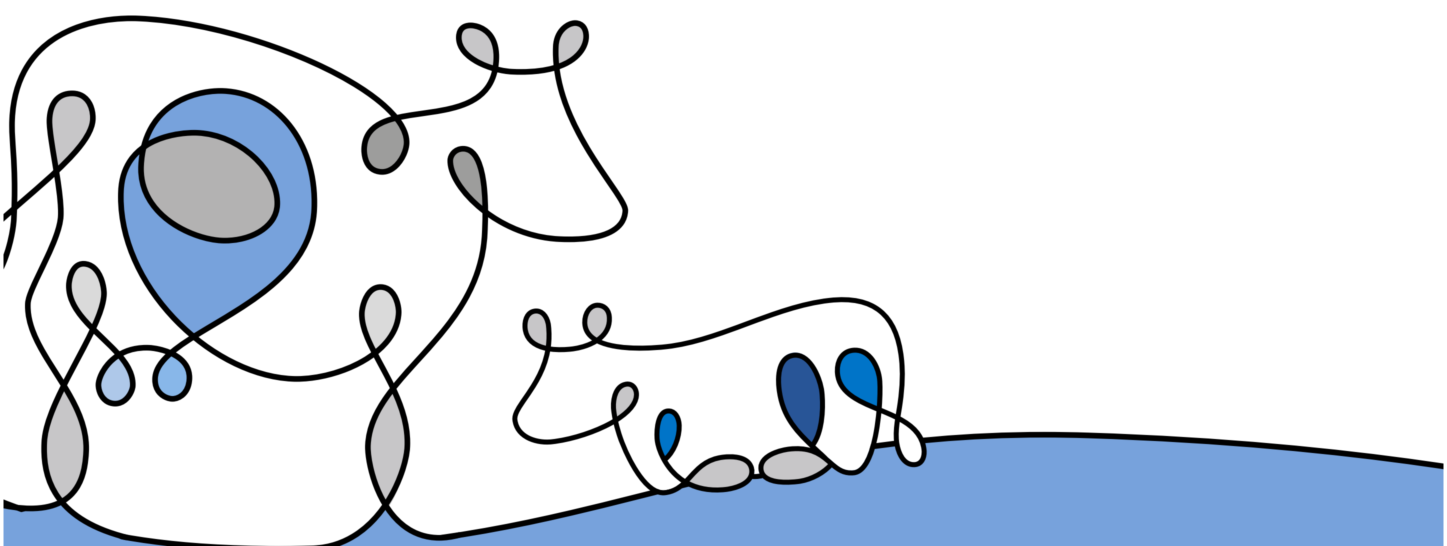


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