ANA PAULA LIMA RIBEIRO

DESENVOLVIMENTO E AVALIAÇÃO DO QUEIJO PETIT SUISSE COM ADIÇÃO DE FARELO DE AVEIA E EDULCORANTES

LAVRAS – MG
2018

ANA PAULA LIMA RIBEIRO

DESENVOLVIMENTO E AVALIAÇÃO DO QUEIJO PETIT SUISSE COM ADIÇÃO DE FARELO DE AVEIA E EDULCORANTES

Dissertação apresentada á Universidade Federal de Lavras, como parte das exigências do Programa de Pós-graduação em Ciência dos Alimentos, área de concentração em Ciência dos Alimentos, para obtenção do título de Mestre.

Prof[a]. Dra. Sandra Maria Pinto
Orientadora

Prof. Dr. Michel Cardoso de Angelis Pereira
Prof. Ph.DLuiz Ronaldo de Abreu
Coorientador

Lavras – MG
2018

Ficha catalográfica elaborada pelo Sistema de Geração de Ficha Catalográfica da Biblioteca Universitária da UFLA, com dados informados pelo(a) próprio(a) autor(a).

Ribeiro, Ana Paula Lima.
Desenvolvimentoe avaliação do queijo petit suisse com adição de farelo de aveia e edulcorantes : melhorias nutricionais no queijo petit suisse / Ana Paula Lima Ribeiro. - 2018.
87 p. : il.

Orientador(a): Sandra Maria Pinto.
Coorientador(a): Michel Cardoso de Angelis Pereira, Luiz Ronaldo de Abreu.
Dissertação (mestrado acadêmico) - Universidade Federal de Lavras, 2018.
Bibliografia.

1. Retenção de soro. 2. Sinerése. 3. Substitutos de sacarose. I. Pinto, Sandra Maria. II. Pereira, Michel Cardoso de Angelis. III. Abreu, Luiz Ronaldo de. IV. Título.

ANA PAULA LIMA RIBEIRO

DESENVOLVIMENTO E AVALIAÇÃO DO QUEIJO PETIT SUISSE COM ADIÇÃO DE FARELO DE AVEIA E EDULCORANTES

DEVELOPMENT AND EVALUATION OF PETIT SUISSE CHEESE WITH ADDITION OF OAT BRAN AND SWEETENERS

Dissertação apresentada á Universidade Federal de Lavras, como parte das exigências do Programa de Pós-graduação em Ciência dos Alimentos, para obtenção do título de mestre.

APROVADAem 16 de fevereiro de 2018
Dra. Larissa de Oliveira Ferreira Rocha UFVJM

Dra. Sandra Maria Pinto
Orientadora

Prof. Dr. Michel Cardoso de Angelis Pereira
Prof. Ph.DLuiz Ronaldo de Abreu
Coorientador

Lavras-MG
2018

Agradecimentos

À Deus, por me fazer acreditar em sua grandeza e em suas obras. Por me ensinar a ser paciente para realizar meu trabalho com alegria e serenidade.

À Universidade Federal de Lavras e ao Departamento de Ciências dos Alimentos pela oportunidade de cursar uma pós-graduação com um ensino de excelência.

À professora Sandra pela confiança e oportunidades de trabalhar ao seu lado por longos anos. Encerro o mestrado com a certeza de que o nosso trabalho foi de muito aprendizado e crescimento na minha vida acadêmica.

Ao professor Luiz Ronaldo por todo o suporte e paciência com as minhas dúvidas e questionamentos. Obrigada por me ensinar a ser inquieta ao aprendizado.

Ao professor Michel por me acolher, me guiar e me ajudar. Sua colaboração foi inestimável.

Aos amigos e colegas de laboratório por todo suporte. Em especial, agradeço à amiga Creuza, por não medir esforços para me auxiliar, pela conversas, risadas e principalmente por fazer parte do meu crescimento pessoal.

Aos meus amigos da UFLA, pessoas as quais dividimos bons momentos juntos, e principalmente aquelas que tornaram meus dias mais leves, e que mesmo longe sempre vão ser lembradas como grandes amigas: Nathane, Dani e Kelly.

As amigas de república, que se tornaram minha família. Ana Paula, Maria Clara, Iara, Lanu, Stefânia: sempre me lembrarei dos bons momentos que estivemos juntas e sentirei saudades.

Aos meus pais, que foram suporte, auxílio e atenção. Pelo amor incondicional, por acreditaram que eu era capaz. À eles, o meu eterno obrigada.

À minha cunhada Daiana, meu irmão Paulo, minha sobrinha Isabela e ao Alex agradeço por tamanha consideração e compreensão. É por vocês que eu desejo ser melhor todos os dias. É a felicidades de vocês que me torna feliz também. Obrigada por torcerem por mim.

Agradeço a agência de fomento Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES) pela colaboração financeira e por acreditar e incentivar a pesquisa no país.

RESUMO

A procura por produtos com maior apelo nutricional tem sido crescente nos últimos anos. Isso ocorre devido à maior consciência do consumidor em relação aos hábitos mais saudáveis. Visando atender as necessidades dos consumidores e aumentar as inovações em um mercado tão competitivo, a indústria de leite inovou com o lançamento de produtos funcionais. Petit suisse é um queijo de sabor suave e adocicado. Atualmente, o mercado de petit suisse é muito voltado para o público infantil. No entanto, petit suisse é um ótimo produto lácteo que deve ser consumido por todas as idades, o que se faz necessário aumentar as pesquisas nessa área. Farelo de aveia é um cereal rico em proteínas, minerais, além de antioxidantes. É muito consumido pelo alto teor de fibras alimentares. Quando consumido regularmente, é capaz de evitar muitas doenças. Além disso, farelo de aveia possui muitas aplicações industriais devido à sua alta capacidade de retenção de água e formação de gel. Dessa forma, no primeiro experimento o objetivo foi 1) incluir farelo de aveia em petit suisse para aumentar a quantidade de nutrientes e fibras alimentares desse alimento com o intuito de atender as necessidades de um público jovem e adulto 2) aproveitar a capacidade de geleificação de farelo de aveia para diminuir a sinérese de petit suisse com retenção de soro e, consequentemente, aumentar a vida de prateleira do produto. As amostras de petit suisse foram fabricadas com 2 concentrações diferentes de espessantes (1% e 2%) e 3 diferentes quantidades de farelo de aveia (3%, 6% e 9%) totalizando 6 tratamentos e dois controles os quais continham apenas 1% ou 2% de espessante e não possuíam farelo de aveia. Foram realizadas análises químicas, fibra alimentar, sinérese, capacidade de retenção de água, perfil de textura instrumental, reologia, tempo de fermentação e atividade de água. Os resultados indicaram que a adição de farelo de aveia em petit suisse proporcionou um aumento nutricional devido à adição de fibras. O acréscimo de farelo de aveia promoveu diminuição na sinérese, aumento da capacidade de retenção de água, aumento nos valores de perfil de textura instrumental e reologia, diminuição da atividade de água e não houve diferença entre os tratamentos no tempo de fermentação. Já no segundo experimento, objetivou-se avaliar diferentes edulcorantes em petit suisse (sucralose, estévia, xilitol e eritritol) e diferentes concentrações de farelo de aveia (3%, 6%, 9% e 12%) para saber a formulação que resultaria em melhor aceitação pelo consumidor. De acordo com os panelistas, a melhor formulação de petit suisse foi com 6% de farelo de aveia, 16% de sacarose, e os substitutos de sacarose que obtiveram melhor aceitação global foram eritritol e xilitol. Os resultados mostraram que o uso de farelo de aveia em petit suisse é uma alternativa que traz benefícios nutricionais para o consumidor e tecnológicos para a empresa. A substituição de sacarose por edulcorantes em petit suisse com adição de farelo de aveia foi bem aceita pelos consumidores.

Palavras-chave: Retenção de soro. Cereal. Substitutos de sacarose.

ABSTRACT

Petit suisse is a cheese, with a smooth and sweet taste. Currently, the petit suisse market is very focused on children. However, petit suisse is a great dairy product that should be consumed by all ages, which makes it necessary to increase research in this area. Oat bran is a cereal rich in protein, minerals, in addition to antioxidants. It is very consumed by high fiber content. When consumed regularly, it is able to avoid many diseases. In addition, oat bran have many industrial applications because of their high water holding capacity and gel formation. The aim of the study was to 1) include oat bran in petit suisse to increase the amount of nutrients and dietary fiber of this food in order to meet the needs of a young and adult population 2) take advantage of oat bran gelling capacity to decrease the syneresis of petit suisse with whey retentate and consequently increase the shelf life of the product. The petit suisse samples were manufactured with 2 different concentrations of thickeners (1% and 2%) and 3 different amounts of oat bran (3%, 6% and 9%), totaling 6 treatments and two controls which contained only 1% or 2% thickener and did not have oat bran. Chemical analysis, dietary fiber, syneresis, water holding capacity, instrumental texture profile, rheology, fermentation time and water activity were performed. The results indicated that the addition of oat bran in petit suisse cheese provided a nutritional increase due to the addition of fiber. The addition of oat bran promoted a decrease in syneresis, increased water holding capacity, increased values of instrumental texture profile and rheology, decreased water activity and there was no difference between treatments at the fermentation time. In the second experiment, the objective was to evaluate different sweeteners in petit suisse (sucralose, stevia, xylitol and erythritol) and different concentrations of oat bran (3%, 6%, 9% and 12%) to know the formulation that would result in consumer acceptance. According to the panelists, the best formulation of petit suisse was with 6% oat bran, 16% sucrose, and the sucrose substitutes that obtained better global acceptance were erythritol and xylitol. The results showed that the use of oat bran in petit suisse is an alternative that brings nutritional benefits to the consumer and technological to the company. Substitution of sucrose by sweeteners in petit suisse with addition of oat bran was well accepted by consumers.

Keywords: Whey retentate. Cereal. Sweeteners.

LISTA DE FIGURAS

LISTA DE TABELAS

PRIMEIRA PARTE

SEGUNDA PARTE - ARTIGOS

Artigo 1

Artigo 2

SUMÁRIO

PRIMEIRA PARTE

1. INTRODUÇÃO

O setor de lácteos no Brasil é um dos mais importantes, apresentando considerado crescimento anual, aumentando as exportações e lançando no mercado os mais variados produtos. O mercado lácteo também é um dos principais em produtos que apresentam linhas de produtos funcionais, que trazem benefícios à saúde do consumidor.

O crescimento de doenças cardiovasculares, pressão alta, obesidade entre outras, fizeram que a população brasileira refletisse sobre os hábitos alimentares. Como consequência, o perfil do consumidor brasileiro mudou em relação a suas escolhas alimentares, a fim de buscar alimentos que possuam maior apelo nutricional. Os consumidores visam alimentos industrializados como fontes extras de nutrientes, fibras e proteínas.

Devido à mudança dos hábitos alimentares e o crescente apelo pela saudabilidade, as indústrias de produtos lácteos estão se adequando ao novo perfil de consumidores, aumentando as linhas de produtos funcionais, ou melhorando linhas já existentes para satisfazer as necessidades e a exigências desse novo público consumidor.

O setor lácteo é considerado um dos setores de maior credibilidade em produtos funcionais, além de ter uma preferência e aceitação por parte dos consumidores. Por isso, se faz necessário desenvolver produtos que atendam as expectativas da população, mas que também sejam inovadores no setor de lácteos, tornando esse mercado mais diversificado.

Petit suisse é um queijo fresco e não maturado, que pode ser acrescido de frutas e/ou outros sabores, por isso é muito consumido como sobremesa. Por ter uma consistência cremosa e sabor adocicado, as empresas possuem o público infantil como consumidor alvo desse produto lácteo. A alta quantidade de sacarose utilizada na formulação desse queijo e o baixo apelo nutricional fazem com que ele tenha baixo consumo pelo público adulto. Preocupados com saúde e maior ingestão de alimentos saudáveis, é necessário tornar o queijo petit suisse mais atrativo nutricionalmente para ampliar o público consumidor desse produto.

O aumento no consumo de sacarose e a baixa ingestão de fibras é uma preocupação no mundo todo. O consumo excessivo de sacarose leva ao aumento de doenças como obesidade, cáries e diabetes. O sabor adocicado agrada tanto o público infantil como o público adulto, fazendo que o consumo de açúcar ingerido pela população seja maior do que o estabelecido diariamentente. Produtos industrializados comprometem a saúde dos consumidores com adição exagerada de açucares em seus produtos. Dessa forma, é importante pesquisar diferentes edulcorantes para substituir a sacarose, com a finalidade de diminuir muitas doenças sem que haja perda no sabor dos alimentos.

O consumo de fibras também é muito importante para manter uma dieta saudável e equilibrada. Beta glucano é uma fibra alimentar solúvel que pode auxiliar na redução do colesterol, e por isso foi reconhecida como alimento funcional pela Agência Nacional de Vigilância Sanitária (ANVISA). Por ser um cereal rico em beta glucano, o farelo de aveia se destaca nutricionalmente diante de outros cereais. Farelo de aveia também é rico em fibras solúveis e insolúveis, proteínas, minerais e antioxidantes. Devido ao seu alto valor nutritivo, o consumo diário de farelo de aveia pode melhorar a saúde intestinal, redução do risco de câncer de cólon e controle do colesterol e glicemia.

Assim como em outros queijos, o soro provindo do processo de fabricação do queijo petit suisse é considerado um resíduo de difícil eliminação na indústria de alimentos. Devido à grande quantidade de lactose, proteínas e sais, o soro quando lançado em rios e mananciais, aumenta a demanda bioquímica de oxigênio (DBO), por isso é considerado altamente poluente. Por isso, as empresas evitam produzir soro, retendo esse soro na massa do queijo com ajuda de espessantes.

Com o intuito de se fazer o uso de aditivos mais naturais, o farelo de aveia se torna grande interesse na indústria de alimentos. O beta-glucano, principal fibra solúvel da aveia, é capaz de formar géis muito viscosos influenciando nas propriedades reológicas dos alimentos. Esse cereal se torna ideal na aplicação de petit suisse com retenção de soro, pois sua capacidade geleificante diminui a sinerese ao longo do tempo e aumenta a vida de prateleira do produto.

Portanto, a combinação de farelo de aveia e edulcorantes em petit suisse com retenção de soro possui benefícios nutricionais para o consumidor, e tecnológicos para o produto, além de diminuir a quantidade de soro gerado, evitando o descarte incorreto desse resíduo na indústria e a conseqüente poluição do meio ambiente. Como resultado, temos um produto que caminha em direção às novas tendências de mercado, além de ampliar o público consumidor, diminuir o consumo de sacarose, aumentar o consumo de fibras, gerando inovação na indústria de alimentos.

2. REFERENCIAL TEÓRICO

2.1 Consumo e produção de leites e derivados no Brasil

De acordo com o Instituto Brasileiro de Georafia e Estatística (IBGE), o Brasil se encontrou na 5º posição de produção de leite, produzindo um total de 35,8 bilhões no ano de 2016. O setor de lácteos desempenha um papel de extrema importância no país, gerando renda e emprego a população brasileira. Seu crescimento ocorre todos os anos entre 2 a 3% devido à adoção de tecnologias as quais otimizam a eficiência de produção, melhoramento genético, e saúde do animal, aumentando a confiança dos consumidores no mercado brasileiro (IBGE, 2016).

A grande variedade de produtos lácteos disponíveis pode ser atribuída em partes pela grande produção leiteira. Dentre os produtos lácteos mais populares, encontram-se os iogurtes e leites fermentados. Devido à praticidade de consumo e a variedade de sabores que estes produtos são comercializados, o consumo é bem aceito por todas as idades. Além disso, Fernandes, Shahani, e Amer (1987) estabeleceram que alguns microrganismos utilizados processo de fabricação de iogurtes e leites fermentados estão relacionados com diminuição de doenças intestinais, pois combatem patógenos.

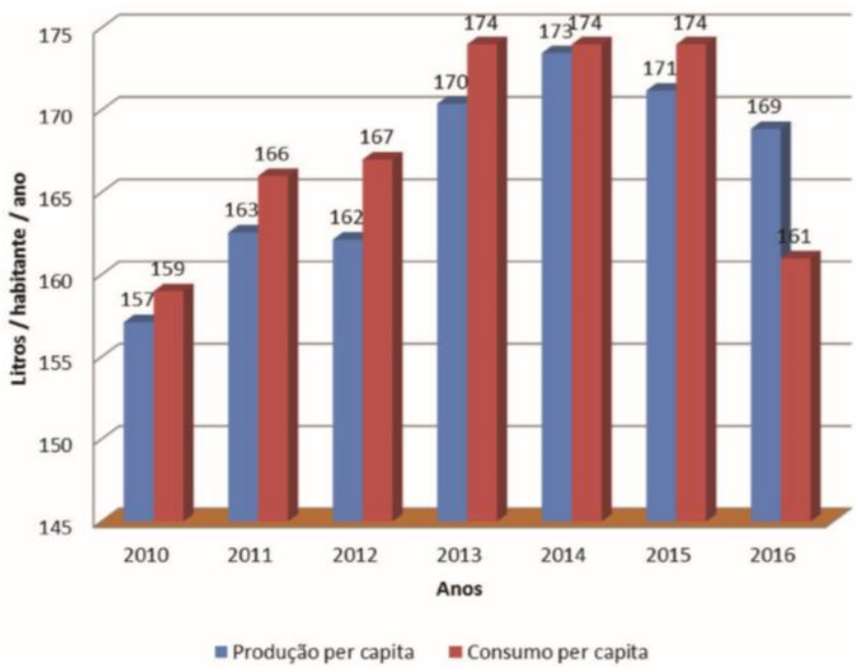
Black et al. (2002) e Silemg (2017) reforçaram que o leite é um alimento de alto valor nutritivo e que se destaca pelas altas concentrações de cálcio comparado a outros alimentos. Esses autores defendem que o cálcio é um mineral essencial necessário em diversas funções biológicas e pode ser encontrado facilmente em leite e produtos lácteos. Apesar da facilidade de se ingerir cálcio, esse nutriente ainda tem sido motivo de preocupação devido ao seu baixo consumo. Além disso, deficiência de cálcio pode acarretar algumas doenças crônicas, por isso, o consumo de leites e derivados deve ser incentivado em todas as idades.

Leite também se destaca por apresentar outros componentes essenciais ao organismo humano. De acordo com Claeys et al. (2013) e Maijala (2000), esse alimento possui proteínas completas, vitaminas como a riboflavina (B2), B12, vitamina A, e por último B6. Também é uma excelente fonte de minerais, como fósforo, zinco, potássio e magnésio.

Alguns autores defendem que a deficiência no consumo de leites e derivados pode causar uma série de doenças como anemia (OLIVEIRA; OSÓRIO, 2005), diminuição da densidade óssea e maiores riscos de fratura (BLACK et al., 2002), deficiência na produção da enzima lactase pelo organismo (COOK; KAJUBI, 1996).

Apesar da vasta quantidade de produtos lácteos oferecidos no mercado atual, o consumo de leite ainda está abaixo do ideal. De acordo com o IBGE, o Brasil teve uma diminuição do consumo de lácteos entre os anos de 2015-2016 (figura 1). Esse cenário é reflexo da inflação e da redução da renda real. No entanto, Vilela et al. (2017) afirma que as expectativas para 2017 é que o país retome a taxa de crescimento histórico para se manter como o quarto maior produtor mundial de leite nos próximos dez anos.

Figura 1. Produção nacional de leite e consumo de lácteos (equivalente) *per capita* no período de 2010 a 2016.



Fonte: IBGE (2016), Brasil Dairy Trends 2020 (2017)

Segudo Vilela et al. (2017) o aumento no consumo de lácteos só será efetivo se consolidar o aumento da renda familiar, o lançamento de novos produtos, menor informalidade no setor e investimentos pesados em pesquisa. Dessa forma, devem-se aumentar as pesquisas em produtos lácteos, com o intuito de melhorar a vasta variedade de produtos já existentes no mercado, e torná-los mais atrativos e nutritivos para os consumidores.

2.2 Queijo Petit Suisse

O queijo petit suisse foi estabelecido pela INSTRUÇÃO NORMATIVA Nº 53, DE 29 DE DEZEMBRO DE 2000 como queijo fresco, não maturado, obtido por coagulação do leite com coalho e/ou de enzimas específicas e/ou de bactérias específicas, adicionado ou não de outras substâncias alimentícias (BRASIL, 2000). Segundo Yuhara, Matsubara e Garcia (2014), a tecnologia de fabricação desse queijo é semelhante à do queijo quark exceto que o queijo petit suisse pode ser acrescido de frutas e polpas e outros saborizantes que o tornam altamente popular. Ainda assim, Fox et al. (2000) determinaram que o queijo apresenta características semelhantes às do queijo quark, como elasticidade, viscosidade e viscoelasticidade, as quais determinam sua textura e influenciam a consistência e a estabilidade final.

Na tecnologia de fabricação desse queijo, além do coalho, também há adição de cultura starter mesófila (*Lactococcus lactis* subsp. *lactis, Lactococcus lactis* subsp. *cremoris*). Alguns autores também concentram suas pesquisas para a utilização dos microrganismos *Lactobacillus casei, Lactobacillus acidophilus, Bifidobacterium animalis* subsp. *Lactis e Lactobacillus sakei* subsp. *Sakei* (BARROS; DELFINO, 2014; SANTOS et al., 2012; VILLARREAL et al., 2013).

Atualmente, petit suise é muito consumido em vários países, principalmente na França onde ele se originou. A base do petit suisse é o queijo quark. No entanto, na sua fabricação não existe a etapa de salga. Por isso, esse queijo pode ser consumido como sobremesa, puro ou acrescido de frutas, o que agrada o paladar principalmente do público infantil.

Apesar de ser um queijo de origem francesa, sua popularidade tem aumentado em vários países (RAMÍREZ-SANTIAGO et al., 2012). No Brasil, alguns autores mostram que esse produto lácteo é muito consumido, principalmente por crianças devido à sua consistência cremosa e sabor doce (PRUDENCIO et al., 2008; RAMÍREZ-SANTIAGO et al., 2012). Pesquisas indicam que o sabor mais comercializado e utilizado é o de morango (CARDARELLI et al., 2008; ESMERINO et al., 2013; PEREIRA et al., 2016).

Em relação à tecnologia aliada à fabricação desse queijo, a literautra nos apresenta diferentes áreas: variação nos microrganismos utilizados fabricação desse queijo (BARROS; DELFINO, 2014), combinação de diferentes gomas na retenção de soro (MARUYAMA et al., 2006) e redução de sacarose (ESMERINO et al., 2013), considerando que esse alimento é consumido principalmente por crianças, levando a obesidade infantil. Existem linhas de pesquisas relacionadas à adição de compostos prebióticos, com o intuito de aumentar a saudabilidade de petit suisse (CARDARELLI et al., 2008).

Como outros queijos, é um produto que após sua coagulação, a massa é dessorada. Segundo Smithers (2008), o soro obtido da dessoragem é uma ótima fonte de proteínas, sais e lactose. Na alimentação humana, o soro lácteo se torna muito nutritivo. No entanto, quando lançado em rios, o soro é altamente contaminante devido ao aumento dos níveis de demanda bioquímica de oxigênio (DBO). Brandelli, Daroit e Corrêa (2015) afirmam que com o intuito de diminuir a quantidade de resíduos gerados, as empresas preferem manter o soro na massa de petit, utilizando de espessantes.

Elorante et al. (2016) exaltaram a importância do consume do queijo petit suisse. Por ser um produto lácteo, o petit suisse é rico em proteínas, carboidratos, vitaminas e minerais e seu consumo deve ser incentivado para todas as idades. No entanto, atualmente no Brasil, petit suisse é um produto lácteo no qual as empresas investem massivamente no público infantil. Por isso, faz-se necessário atender aos consumidores e suas necessidades, para criar um petit suisse que atenda ao público adulto, tornando-o assim não apenas uma sobremesa, mas também uma fonte nutritiva e saudável.

2.3 Estratégias e inovações no setor lácteo voltado para o queijo petit suisse

Antes de lançar um produto no mercado é imporntante criar estratégias para se obter sucesso com o novo produto. Segundo Bimbo et al. (2017), para se criar um produto inovador, é necessário, primeiramente, entender as necessidades dos consumidores. Atender as necessidades dos consumidores beneficia tanto os usuários como os fabricantes. E com esse intuito, o setor lácteo cresceu muito nas últimas décadas, trazendo mudanças que agregaram valor aos produtos.

Bigliardi e Galati (2013) reforçaram que as empresas têm se esforçado para inovar e criar novos produtos para atender aos consumidores e aumentar a competitividade entre empresas que participam do mesmo ramo alimentício. No entanto, segundo Prudencio et al. (2008), no Brasil ainda faltam pesquisas sobre o queijo petit suisse com o intuito de tornar esse queijo mais atrativo para a população adulta, pois atualmente seu consumo é muito voltado apenas para o público infantil.

A crescente demanda pelo corpo perfeito, pela saudadabilidade, ou muitas vezes devido aos problemas como diabetes e obesidades, muitos consumidores optam por produtos *diets* e *lights.* Dessa forma, crescem o número depesquisas por substitutos de sacarose em petit suisse como sucralose, aspartame, estévia, entre outros (SOUZA et al., 2011; ESMERINO et al., 2013).

As tendências para produtos fortificados começaram a aumentar gradativamente com o aumento das deficiências no consumo de nutrientes. Dessa forma, Salgueiro et al. (2005a) investigaram a adição de zinco em petit suisse como uma maneira de superar a deficiência de zinco em adultos. Salgueiro et al. (2005b) também obtiveram sucesso na adição de zinco em petit suisse para ganho de peso em crianças desnutridas. De acordo com Holick e Chen (2008), produtos lácteos fortificado com sulfato de zinco, ferro, cálcio e vitamina D buscam suprir as necessidades diárias desses nutrientes, agregando valor ao produto. A adição de nutrientes em petit suisse é uma alternativa para consumo de produtos fortificados, fazendo que esse produto tenha apelo para todos os públicos.

Uma classe de alimentos que têm ganhado força no setor de produtos lácteos são os alimentos funcionais. Ozer e okirmaci (2010) e Ares e Deliza (2010) afirmaram que o setor lácteo é um dos setores que mais possui produtos funcionais como ingredientes. Por isso que também é o setor que mais atrai consumidores que consomem produtos adicionados de ingredientes funcionais.

Produtos funcionais atendem muito mais a expectativa dos consumidores do que produtos convencionais, por isso Pappalardo e Lusk (2016) observaram a importância de se investir nesse tipo de seguimento. De acordo com Laureati et al. (2016), o acréscimo de produtos funcionais pode ser uma jogada de marketing para aumentar a popularidade do produto, ou até mesmo para melhorar as características tecnológicas para fabricação dos alimentos.

Bimbo et al. (2017) apontam que mulheres e/ou pessoas altamente preocupada com hábitos saudáveis, sendo o público com grande aceitação por produtos lácteos funcionais. Apesar de o setor lácteo ser um bom alvo para esses produtos, as pesquisas com adição de fibras e outros alimentos considerados pela ANVISA como funcionais ainda se concentram apenas em leites fermentados. Alguns autores reforçam que ainda faltam pesquisas na área de queijos como produtos funcionais (LIMA; RÉVILLION; PADULA 2009; ALE et al., 2016). Apesar do queijo petit suisse ser um produto muito consumido em vários países e nas mais variadas formas, ainda não foi associado com elementos funcionais que agregam valor ao produto e aumentam o seu valor nutritivo.

2.4 Produtos alimentícios funcionais

Os produtos alimentícios funcionais vêm se tornando muito famosos no mercado atual. Dentre eles temos pães, biscoitos, leites e derivados. Pappalardo e Lusk (2016) afirmam que produtos alimentícios funcionais têm uma melhor aceitação que os produtos convencionais. Isso ocorre porque muitos consumidores não são adeptos a ingestão de suplementos ou fontes diretas de nutrientes como cereais ou grãos. No entanto, quando vitaminas, minerais e complementos funcionais são adicionais a alimentos que possuem maior aceitação, eles se tornam de fácil ingestão e ainda aumentam o valor nutritivo do alimento que recebe esse complemento.

É importante salientar a diferença entre alimentos funcionais e alimentos enriquecidos. De acordo com Resolução nº 18, de 30 de abril de 1999 estabelecida pela ANVISA, alimentos funcionais apresentam papel metabólico ou fisiológico. Como exemplo, temos os nutrientes (ex. fibras) ou não nutrientes (ex. licopeno) que participam do crescimento, desenvolvimento, manutenção e outras funções do organismo. Brasil (1999) ainda estabelece que o alimento ou ingrediente que alegar propriedades funcionais ou de saúde pode, além de funções nutricionais básicas, quando se tratar de nutriente, produzir efeitos metabólicos e ou fisiológicos e ou efeitos benéficos à saúde, devendo ser seguro para consumo sem supervisão médica.

Já os alimentos fortificados/enriquecidos, ou simplesmente adicionado de nutrientes, é todo alimento ao qual for adicionado um ou mais nutrientes essenciais tais como vitaminas, minerais e ou aminoácidos, em quantidades definidas em regulamento específico, com o objetivo de reforçar o seu valor nutritivo e ou prevenir ou corrigir deficiência(s) demonstrada(s) em um ou mais nutrientes, na alimentação da população ou em grupos específicos da mesma (BRASIL, 1999).

O mercado lácteo é um setor que tem apresentado os mais diversos produtos enriquecidos. Dessa forma, além dos benefícios de consumo do leite também são adicionados outras vitaminas, minerais ou nutrientes que tornam esses produtos mais atrativos. Além disso, os produtos lácteos enriquecidos podem contribuir para a diminuição de muitas deficiências no país. Como exemplo, Oliveira e Osório (2005) citaram a anemia ferropriva que está associada a muitos fatores, dente eles a ingestão deficiente de ferro. O leite modificado enriquecido de ferro, por outro lado, reduziria a chance de anemia pelo aumento da densidade de ferro no leite.

O desenvolvimento de produtos lácteos funcionais também é uma área de expansão importante na indústria de lácteos, onde centenas de novos produtos são desenvolvidos a cada ano, constituindo um dos maiores setores do mercado global de alimentos funcionais. Ortiz et al. (2017) reforçam que os consumidores do século XXI, estão buscando benefícios além da nutrição em seus alimentos, escolhendo aqueles que proporcionam bem-estar, conveniência e saúde melhorada além da nutrição básica. Consciente dos beneficios dos alimentos estabelecidos como funcionais, a indústria tem investido em pesquisas que combinem alimentos funcionais aos mais diversos produtos lácteos.

De acordo com Ayyappan et al. (2016), os principais princípios empregados na formulação de produtos lácteos funcionais estão relacionados com a adição de microrganismos probióticos e fibras que estimulam o crescimento e a atividade de bactérias intestinais. Além de probióticos e prebióticos, Ortiz et al. (2017) mostraram que a popularidade de fitoesteróis, ácido linoleico conjugado, ácidos graxos ômega-3, minerais e peptídios bioativos estão aumentando devido à necessidade de lidar com problemas de saúde que vão de simplesmente manter a saúde gastrointestinal ao controle da hipertensão, reduzir o colesterol e melhorar a resposta do sistema imunológico, entre muitas outras preocupações com a saúde.

Para ser considerado um produto funcional, o alimento deve ser aprovado e registrado na ANVISA. A tabela 1 mostra alguns alimentos que são considerados funcionais e suas respectivas alegações de propriedade funcional.

Tabela 1. Lista de algumas substâncias considerados funcionais pela ANVISA e suas respectivas legações de propriedades funcionais

Alimento	Alegação de propriedade funcional
Fibras alimentares	Funcionamento do intestino
Beta glucano	Redução de colesterol
Frutologossacarídeos FOS	Equilíbrio da microbiota intestinal
Inulina	Equilíbrio da microbiota intestinal
Manitol, xilitol, sorbitol	Não produz ácidos que danificam os dentes
Proteína de soja	Reduz colesterol
Quitosana	Reduz absorção de gordura
Licopeno	Ação antioxidante

Probioticos	Diferente para cada MO (Resolução n. 18/1999.)

Fonte: Adaptado de BRASIL(1999).

2.5 Aveia

Aveia (*Avena sativa*) é um cereal cultivado em muitas partes do mundo como Canadá, Brasil, EUA, China, Austrália e climas mais úmidos do noroeste da Europa. Aveia é um cereal utilizado em rotação de cultura como uma cultura de cobertura. Strychar (2011) explicou que seu plantio é mais voltado para alimentação animal por ser uma boa fonte de proteínas, fibras e minerais, além de ser um cereal barato para se planter e comercializar. Também é utilizado na alimentação humana de várias formas, como farelo, farinha e flocos de aveia.

Vários autores defendem o consumo de aveia devido às suas propriedades nutricionais, como podem ser ilustradas na tabela 2. Estudos apontam que aveia é um cereal que fornece energia, proteínas (CAI et al., 2012), minerais, fibras, além de compostos bioativos para o corpo os quais reduzem os riscos de doenças coronárias (TSOPMO, 2015; AKKOL et al., 2011), câncer entre outros. Por isso, Alrahmany, Avis, e Tsopmo (2013) reforçam que o incentivo ao consumo de aveia deve ser aumentado considerando que, além da alta quantidade de nutrientes, o grão também possui alta quantidade de compostos antioxidantes que previnem doenças.

Tabela 2. Composição química do grão de aveia

Componente	Quantidades expressas em porcentagem (%)
Umidade	13,3
Proteínas	13
Lipídios	7,5
Fibras	10,3
Cinzas	3,1
Cálcio (mg/100g)	60
Fósforo (mg/100g)	372
Ferro (mg/100g)	3,8
Zinco (mg/100g)	3,9

Iodo (mg/100g)	16
Tiamina (mg/100g)	0,5
Riboflavina (mg/100g)	0,14
Niacina (mg/100g)	1,3

Fonte: Kirk e Sawye (1999)

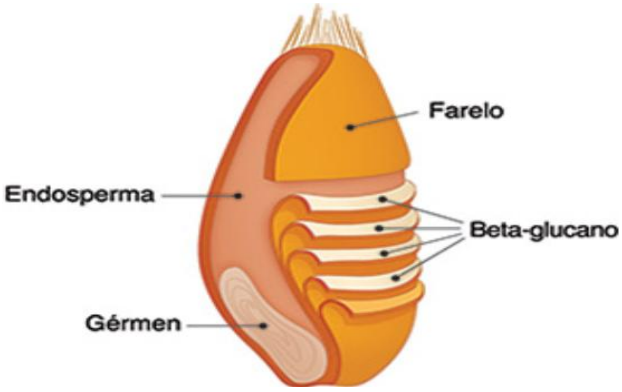
Aveia também é conhecida pela quantidade de antioxidantes e compostos fenólicos presentes no grão. Avenanthramides é um alcalóide, identificado por Collins (1989) que contém um grupo fenólico, o qual exibe atividade antioxidante in vitro e in vivo, em diferentes tipos de células. Atualmente, esse composto ainda é visto por alguns autores como o grupo de antioxidante mais importante desse cereal por ser único e encontrado apenas na aveia (PETERSON, 2001; FULGONI et al., 2015). Dimberg et al. (1999) mostraram que a quantidade de Avenanthamides encontrada pode variar de 2 – 700 $mg.kg^{-1}$, mas isso dependerá da espécie, da região de cultivo e do tratamento de extração desse antioxidante.

Os compostos fenólicos presentes em todo o grão de aveia são de grande interesse por sua habilidade de seqüestrar espécies reativas de oxigênio (ROS) e proteger as moléculas do corpo humano, como DNA, lipídios ou contra oxidação de colesterol. Esses compostos são represetandos por vitamina E, ácidos fenólicos, flavonóides, esteróis e ácido fítico como foi estudado por alguns autores (PETERSON, 2001; FULGONI et al., 2015). Walters et al. (2018) mostraram que a aveia é um cereal rico em ácido cumárico, ferúlico, vanílico, cafeico e cinâmico, ácidos que apresentam alta taxa de combate a radicais livres.

Também é muito reconhecida por alguns autores por diminuir a incidência de doenças crônicas como o câncer e doenças cardiovasculares (ALRAHMANY; TSOPMO, 2012), reduzir o colesterol plasmático total e o nível de colesterol de lipoproteínas de baixa densidade, glicemia pós-prandial e resposta à insulina, ocorrência de doença cardíaca coronária, inflamação crônica das artérias e desenvolvimento de câncer e aterosclerose (RASANE et al., 2013). Dessa forma, se faz necessário aprofundar os estudos nesse cereal, com o intuito de aplicar os compostos fenólicos existentes na aveia como aditivo na indústria de alimentos.

Segundo Ndolo e Beta (2013), para a indústria, as três frações principais da aveia são farelo, endosperma e gérmen, como pode ser representado pela figura 2, no qual o farelo representa 8,7%, o endosperma 89,5% e o gérmen 1,8% do peso do grão.

Figura 2. Morfologia do grão de aveia



Fonte: https://www.lisia-kiehl.com.br/noticias/

A casca da aveia representa 25% do peso seco do grão. A casca de aveia foi considerada por muito tempo como um resíduo sem valor para indústria. Além disso, muitas vezes era descartada de forma incorreta causando problemas para o meio ambiente. Para melhorar a forma de utilização da casca, Furlan, Duarte, e Mauler (2012) mostraram que a geração de energia e compósitos são algumas das utilidades encontradas para a casca.

Já o farelo de aveia, também conhecido comercialmente como *oat bran*, representa 8,7% do peso do grão, e é a porção da aveia que possui maior concentração de fibras alimentares como β-glucano. Por isso seu consumo é visto de forma positiva por alguns autores, devido a sua capacidade de diminuir o colesterol e os níveis de glicose no sangue (GAMEL et al., 2014), doenças coronárias (FDA, 1997), e câncer de cólon (BUTT, 2008).

A maior parte do grão é representada pelo endosperma (89,5%), rico em α-tocotrienol, que é uma forma diferente da vitamina E, considerado de grande capacidade antioxidante (BROECK et al., 2016). O gérmen da aveia apresenta 1,8% do peso do grão e é rico em vitamina E (α-Tocopherol) e minerais.

Devido ao seu alto valor nutricional, aveia pode ser aplicada a produtos como pães, biscoitos e alimentos infantis. A aveia é muito consumida no café da manhã na forma de mingau, farelo ou flocos. As frações menores de farinha possuem maior quantidade de proteína, fazendo que a farinha seja ótima para o consumo humano. Além disso, Butt et al. (2008) reforça vantagens na farinha de aveia, que também pode ser usada na área de panificação em substituição a farinha de trigo ou até mesmo o uso combinado das duas farinhas.

Aveia é um cereal de grande interesse principalmente na área de panificação. O grande interesse em aveia ocorre, pois muitos autores alegam que é bem tolerado por pacientes celíacos (PINTO-SÁNCHEZ et al., 2017; SOUZA et al., 2016; TAPSAS et al., 2014), o que se torna muito interessante para ser aplicado na dieta de pessoas as quais o organimos não suporta a presença de proteínas formadoras de glúten. Por isso, pesquisas têm aplicado farelo de aveia em formulações de pães, cookies (DUTA; CULETU, 2015) e outras massas (PADALINO et al., 2011) com apelo glúten *free*. No entanto, Vieille et al. (2016) mostraram que ainda não há consenso sobre a ingestão segura de aveia por pacientes celíacos, principalmente devido a contaminação que aveia pode sofrer no campo, no armazenamento com outros cereais, ou até mesmo diferenças em cultivares que podem levar a reações adversas pelos pacientes celíacos.

2.6 Fibras

Fibras dietéticas são essênciais na alimentação humana. São polissacarídeos de origem vegetal que não são digeridas no trato gastrointestinal superior humano, mas que posseum grande importância no corpo humano. De acordo com a Comissão do *Codex Alimentarius* (2006), as fibras alimentares são carboidratos comestíveis encontrados naturalmente nos alimentos. Essas fibras não são nem digeridas nem absorvidas no intestino delgado e possuem as propriedades: redução no nível sanguíneo de colesterol total e/ou LDL-colesterol, redução no nível sanguíneo pós-prandial de glicose e/ou insulina, tempo de trânsito intestinal reduzido e estimular a fermentação colônica.

As fibras dietéticas são divididas em dois grupos: fibras solúveis e fibras insolúveis. De acordo com Mattos e Martins (2000), a diferença entre essas duas fibras ocorre, pois as fibras solúveis são assim denominadas devido à sua capacidade de solubilizar em água fazendo que haja aumento da viscosidade do conteúdo intestinal e redução do colesterol plasmático. Já ás fibras insolúveis na presença de água aumentam o volume do bolo fecal, reduzem o tempo de trânsito no intestino grosso, facilitando a eliminação fecal, contribuindo para a redução do risco de alguns males do cólon.

Aveia é um cereal conhecido por ser rico em fibras alimentares, como pode ser ilustrado na tabela 3. Chawla e Patil (2010) mostraram que a quantidade total de fibras no grão varia de 7,1% a 12,1% dependendo do cultivar. Heini et al.(2016) observou que as fibras dietéticas de aveia são diferentes dos outros grãos de cereais devido ao seu elevado teor de β-glucano, que é uma fibra solúvel que ocorre nas paredes do endosperma e possui (1 → 3) ligações glicosídicas que resultam na estrutura β(1 → 3) (1 → 4)-p-D-glucano. A Administração de Alimentos e Medicamentos dos Estados Unidos (FDA) mostrou que o consumo diário de 3g de fibra de beta-glucano solúvel a partir de farelo de aveia levará a uma redução de 5 a 8% no nível total de colesterol no plasma (FDA,1997). Ladjevardi et al. (2016) concluiram que, devido à solubilidade em água, o β-glucano atua como um pré-antibiótico, melhorando a atividade de microrganismos intestinais e aumentando sua sobrevivência, por isso é muito adequado para produtos lácteos.

Tabela 3. Quantidade de fibra dietética em cereais

	Fibra dietética (g/100)		
Grãos	Total	Insolúvel	Solúvel
Cevada	17,3	-	-
Milho	13,4	-	-
Aveia	10,3	6,5	3,8
Arroz	1,3	1	0,3
Trigo	12,6	10,2	2,3
Gérme de trigo	14	12,9	1

Fonte: Dhingra et al., 2012

O farelo é a porção da aveia que possui maior quantidade de fibras. A Associação Americana de Química Clínica (AACC) define que o farelo de aveia possui um teor de fibra dietética total de pelo menos 16,0% (base em peso seco) e, pelo menos, um terço da fibra dietética total é fibra solúvel (AACC, 2016). De acordo com Butt et al. (2008), o farelo é a camada comestível mais externa do grão de aveia e é produzido pela moagem de grãos limpos, seguido de peineiração e flocagem modo que o farelo de aveia não seja superior a 50% do início material. Além disso, possui quantidades β-glucano não inferior a 5,5% e pelo menos um terço da fibra alimentar total é fibra solúvel, como foi estabelecido pela AACC (1989).

Por conter alta quantidade de fibras e de β-glucano, o farelo de aveia se encaixa como um ingrediente com alegação funcional. De acordo com a ANVISA (1999), as fibras alimentares auxiliam o funcionamento do intestino e seu consumo deve estar associado a uma alimentação equilibrada e hábitos de vida saudáveis. Além disso, para que um produto tenha apelo de alimento funcional, ele deve fornecer no mínimo 2,5 g de fibras na porção, sem considerar a contribuição dos ingredientes utilizados na sua preparação. Portanto, o uso de aveia é muito adequado em produtos lácteos a fim de torná-los produtos funcionais.

2.7 Importância Tecnológica das fibras

Assim como foi estabelecido por Dhingra et al. (2012), fibras dietéticas contém todas as características necessárias para serem consideradas como importantes na formulação de alimentos funcionais, devido aos seus efeitos benéficos para a saúde. No entanto, quando aplicadas a alimentos, elas também modificam a textura, consistência e propriedades reológicas do produto, sendo ótimas aliadas à tecnologia de produtos alimentícios.

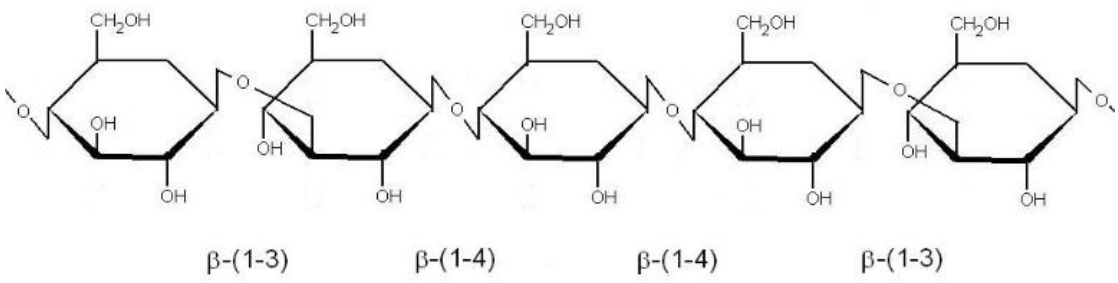
Portanto, Elleuch et al. (2011) estabeleceram que muitas fibras são utilizadas como ingredientes funcionais para melhorar as propriedades físicas e estruturais da hidratação, capacidade de retenção de óleo, viscosidade, textura, características sensoriais e vida útil de alimentos.

Muitas pesquisas foram feitas para acrescentar aveia em diferentes alimentos com o intuito de aumentar o valor nutricional e melhorar as características sensoriais e tecnológicas dos mesmos. Alakhrash et al. (2016) observaram que a fortificação de surimis com 6% de aveia resultava em um gel com textura aprimorada, capacidade de retenção de água e perda de cozimento durante a formação do gel de surimi. Com adição de 9% de farinha de aveia em nuggets de carne de carneiro apresentaram significativamente ($p<0,05$) maior estabilidade da emulsão, alta percentagem de capacidade de retenção de água, e melhores características organolépticas, como sabor, suculência e aceitabilidade geral em comparação com outros tratamentos e ao controle. Mehta et al. (2013) investigaram o uso de fibras como substituto de gordura na fabricação de vários produtos à base de carne para gradações tecnológicas, como melhora nos rendimentos culinários, propriedades reológicas, redução dos custos da formulação e aumento da palatabilidade e textura desses produtos.

Aveia também foi acrescentada em produtos de panificação. Nazir et al. (2017) mostraram que a adição de 10% de farinha de aveia em massas de pão melhora a extensibilidade da masssa. Além disso, Zhang et al. (1998) investigaram os efeitos do β-glucano da aveia em panificação, encontrando que essa fibra é responsável pelo aumento dos requisitos de absorção e mistura de água quando comparado à massa de trigo. Sanchez-Pardo et al. (2010) relataram melhoria na textura de bolo quando incorporou 25% de fibra de aveia na massa. No entanto, Rasane et al. (2013) concluiram que devido à falta de glúten, não há propriedades viscoelásticas adequadas para panificação, o que faz com quem a farinha de aveia ainda pouco apropriada para substituir integralmente a farinha de trigo.

O β-glucano, principal fibra solúvel da aveia, possui grande capacidade de retenção de água. Mudgil e Barak (2013) explicaram que essa característica ocorre devido ao tipo de ligação que a molecula possui, β(1 → 3) e β(1 → 4). Diferente das ligações β(1 → 4), as ligações β(1 → 3) proporcionam maleabilidade a molécula e impedem a ciclização da mesma, fazendo que a molecula seja altamente hidrofílica como pode ser demonstrado pela figura 3.

Figura 3. Estrutura da molecula de β-glucano de aveia.



Lazaridou et al. (2003) mostraram que em pequenas quantidades, β-glucano pode conferir alta viscosidade a soluções aquosas devido ao seu alto peso molecular, conformação e propriedades interativas. Outros estudos concluem que β-glucano também possui características reológicas desejáveis, como aumento da viscosidade e propriedades de gelificação (PETERSSON et al., 2014; LAZARIDOU et al., 2014), o que torna essa fibra muito atraente como aditivo para a indústria de alimentos.

2.8 Importância do estudo de substitutos de sacarose

A sacarose é um ingrediente importante na alimentação, pois fornece energia ao organismo, No entanto, seu consumo excessivo é motivo de preocupação pelos órgãos brasileiros. Shankar, Ahuja e Sriram (2013) afirmaram que o consumo de açúcar faz parte da nossa dieta, no entanto, é um dos principais carboidratos responsáveis por obesidade, cáries, hipertensão, doenças cardiovascularesna população adulta. Além disso, nota-se no Brasil um aumento de diabetes e obesidade devido à mudança de hábitos da população e aumento no consumo excessivo de sacarose.

De acordo com o Ministério da Saúde, entre os anos de 2006-2016, pessoas diagnosticadas com diabetes aumentaram em 61,8%. Esse resultado está relacionado a mudança de hábitos alimentares, principalmente ao consumo excessivo de doces. A pesquisa também nos informa que o hábito no consumo excessivo de doces é maior entre mulheres (19,7%) do que entre homens (16,0%) e entre jovens de 18 a 24 (26,2%) seguido pela faixa etária de 25 a 34 (20,6%).

Além disso, uma pesquisa publicada pelo Ministério da Sáude em 2017, revela o aumento da obesidade no Brasil. Segundo o levantamento, uma em cada cinco pessoas no país está acima do peso. A prevalência da doença passou de 11,8%, em 2006, para 18,9%, em 2016. A pesquisa informa que o índice de obesidade aumenta com o avanço da idade, no entanto, 17% dos brasileiros na faixa etária entre 25 a 44 anos encontram-se acima do peso.

Segundo o Ministério do Desenvolvimento Social, no ano de 2014 o Brasil se encontrava no quarto lugar no ranking dos maiores consumidores de açúcar do mundo. O consumo excessivo de açúcares pela população brasileira está relacionado ao consumo de sucos, refrigerantes e refrescos, adicionados de açúcares, aliado ao baixo consumo de frutas e hortaliças.

A Organização Mundial da Saúde (OMS) estabelece que o consumo diário de açúcar não deve ultrapassar de 50 gramas. Uma pesquisa realizada pelo POF 2008-2009 mostrou que 61,3% da população brasileira consomem açúcar em excesso. Segundo a pesquisa, a recomendação diária é que apenas 10% do açúcar que venha de alimentos, no entanto, a média de energia diária proveniente do açúcar livre para cada pessoa foi 14% do total, 4% acima do estabelecido.

Diantes dos dados, se faz necessário alertar a população em relação aos riscos do consumo excessivo de açúcar. Também são necessárias pesquisas que busquem substitutos de sacarose para produtos industrializados. Os edulcorantes vêm sendo utilizado pela indústria de alimentos como uma alternativa à sacarose.

Os substitutos da sacarose possuem muitas vantagens. Kroger, Meister e Kava (2006) mostraram que os edulcorantes permitem que as empresas produzam produtos que possuem benefícios aos consumidores, com baixa caloria, e com gosto muito similiar ao da sacarose. Apesar da grande quantidade de substitutos oferecidos pelo mercado, se faz importante estudar substitutos de açúcar para diferentes produtos para encontrar o que mais agrada o consumidor, que menos possui gosto residual, e que mais se assemelha a sacarose.

Aggarwal, Sabikhi e Kumar (2016) afirmam que a mudança de hábitos da população e a crescente demanda de doenças relacionadas ao excessivo consumo de açúcar, faz com que a indústria de alimentos foque no desenvolvimento de produtos com baixas quatidade de calorias e rica em fibras como uma resposta para um público que interessado em alimentos funcionais. Por isso, a combinação de petit suisse com farelo de aveia e edulcorantes faz com que esse produto siga as tendências do mercado, satisfazendo as necessidades dos consumidores, e agregando valor nutricional a produto com baixas calorias.

3. CONSIDERAÇÕES FINAIS

A busca por inovações no mercado alimentício tornou-se imprescindível, devido ao aumento da concorrência entre empresas e aos consumidores mais exigentes. Além disso, os consumidores têm buscado emprodutos industrializados não apenas sabor, mas produtos que sejam nutricionalmente saudáveis ajudando a manter uma dieta equilibrada. Por isso, o objetivo das empresas de alimentos é a inovação através do desenvolvimento de produtos com aumento nutricional e sensorial para satisfazer as necessidades do consumidor moderno. O incremento de farelo de aveia em petit suisse possui tantos benefícios nutricionais como tecnológios. A aveia é rica em muitos nutrientes e fibras. A adição de fibras em produtos lácteos faz que ele se torne mais atrativo nutricionalmente para o consumidor. As fibras solúveis, como o β-glucano, possui propriedades de formar géis e mudar as propriedades reológicas, mesmo quando aplicadas em baixas quantidades. Isso se torna de grande interesse na indústria, utilizando essas fibras para substituir espessantes. Portanto, utilizar de farelo de aveia na formulação de queijo petit suisse, não apenas aumenta as características nutricionais, devido à alta quantidade principalmente de fibras solúveis, mas também oferece ao consumidor uma alternativa de sabor e textura para consumo do petit suisse sabor aveia.

REFERÊNCIAS

AACC. Committee adopts oat bran definition. **Cereal Chem**, p. 1–2, .1989.

AGGARWAL, D.; SABIKHI, L.; KUMAR, M.H.S.Formulation of reduced-calorie biscuits using artificial sweeteners and fat replacer with dairy–multigrain approach. **NFS Journal**, v. 2, p. 1-7, 2016.

AKKOL, E. K. et al. Assessment of Dermal Wound Healing and in Vitro Antioxidant Properties of Avena Sativa L.**Journal of Cereal Science,**v. 53, n. 3, p. 285–290, 2011.

ALAKHRASH, F.; ANYANWU, U.; TAHERGORABI, R.Physicochemical properties of Alaska pollock (*Theragra chalcograma*) surimi gels with oat bran. **LWT - Food Science and Technology,**v. 66, p. 41-47, 2016.

ALE, E.C. et al.Exopolysaccharide from Lactobacillus Fermentum Lf2 and Its Functional Characterization as a Yogurt Additive.**Journal of Dairy Research**, v. 83,p. 487–492, 2016.

ALRAHMANY, R.; AVIS, T.J.; TSOPMO. A. Treatment of Oat Bran with Carbohydrases Increases Soluble Phenolic Acid Content and Influences Antioxidant and Antimicrobial Activities.**Food Research International,**v. 52,n. 2, p. 568-574, 2013.

ALRAHMANY, R.; TSOPMO. A. Role of Carbohydrases on the Release of Reducing Sugar, Total Phenolics and on Antioxidant Properties of Oat Bran.**Food Chemistry**,v. 132, n. 1, p. 413-418, 2012.

ANTTILA, H.; SONTAG-STROHM, T.; SALOVAARA, H. Viscosity of beta-glucan in oat products. **Agricultural and Food Science**, v. 13, p. 80–87, 2004.

ARES, G.; DELIZA. R.Identifying Important Package Features of Milk Desserts Using Free Listing and Word Association.**Food Quality and Preference**,v. 21, n. 6, p. 621-628, 2010.

AYYAPPAN, P. et al. Physicochemical Properties of Cookies Enriched with Xylooligosaccharides.**Food Science and Technology International,**v.16, p. 1–9, 2016.

BARROS, L.S.S., DELFINO, N. DE C. Petit-Suisse Cheese Production with Addition of Probiotic Lactobacillus Casei.**Food and Nutrition Sciences,**v. 5,p. 1756–1764, 2014.

BIGLIARDI, B.; GALATI, F. 2013. Innovation Trends in the Food Industry : The Case of Functional Foods.**Trends in Food Science & Technology,** v. 31, n. 2, p. 118–129, 2013

BIMBO, F. et al. Consumers' Acceptance and Preferences for Nutrition-Modi Fi Ed and Functional Dairy Products : A Systematic Review.**Appetite**, v. 113, n. 1, p. 141-154, 2017.

BLACK, R.E. et al. Children Who Avoid Drinking Cow Milk Have Low Dietary Calcium Intakes and Poor Bone Health 1 – 3.**The American Journal of Clinical Nutrition**, v. 76, p. 675–80, 2002.

BRANDELLI, A.; DAROIT, D.J.; CORRÊA,A.P.F. Whey as a Source of Peptides with Remarkable Biological Activities. **Food Research International**, v.73, p. 149-161, 2015.

BRASIL. Agência Nacional de Vigilância Sanitária. Resolução RDC nº 18, de 30 de abril de 1999. Aprova as **Diretrizes básicas para análise e comprovação de propriedades funcionais e ou de saúde alegadas em rotulagem de alimentos.**

BRASIL. Agência Nacional de Vigilância Sanitária.Portaria n º 31, de 13 de janeiro de 1998. Aprovar o Regulamento Técnico referente a Alimentos Adicionados de Nutrientes Essenciais. **Diário Oficial [da]República Federativa do Brasil,**1998.

BRASIL. Ministério da Agricultura, Pecuária e do Abastecimento. Instrução Normativa n° 53, de 29 de dezembro de 2000. Dispõe sobre o Regulamento Técnico de Identidade e Qualidade de Queijo Petit-suisse. **Diário Oficial [da]República Federativa do Brasil,** Brasília, 2000.

BRASIL DAIRY TRENDS 2020. Zacarchenco, Patrícia Blumer; Van Dender, Ariene Gimenes Fernandes; Rego, Raul Amaral. – 1. ed. – Campinas : ITAL, 2017. Disponível em: file:///E:/brasil%20trends.pdf. Acesso em: 20 de janeiro de 2018.

BRASIL. 2014. Ministério do Desenvolvimento Social e Agrário. Acesso em 27 de ferevereiro de 2018. http://www.mds.gov.br/area-de-imprensa

BRASIL. 2017. Ministéripo da Saúde. Acesso em 27 de ferevereiro de 2018http://portalms.saude.gov.br/noticias/sas/41846-diabetes-aumenta-no-pais-e-ja-atinge-9-dos-brasileiros

BRASIL. 2017. Ministéripo da Saúde. Acesso em 27 de ferevereiro de 2018. http://www.brasil.gov.br/saude/2017/04/obesidade-cresce-60-em-dez-anos-no-brasil

BROECK, H. van den. et al. Profiling of Nutritional and Health-Related Compounds in Oat Varieties. **Foods,** v. 5, n. 2, 2016.

BUTT, M.S. et al. Oat : Unique among the Cereals.**European Journal of Nutrition**, v. 47, p. 68–79, 2008.

CAI, S. et al. Comparative Study of the Effects of Solid-State Fermentation with Three Filamentous Fungi on the Total Phenolics Content (TPC), Flavonoids, and Antioxidant Activities of Subfractions from Oats (Avena Sativa L.).**Journal of Agricultural and Food Chemistry**,v. 60, n. 1, p. 507–513, 2012.

CHAWLA, R., PATIL, G.R. Soluble Dietary Fiber. **Comprehensive Reviews in Food Science and Food Safety**, v. 9, n. 2, p. 178–196. 2010.

CARDARELLI, H. R. et al. Inulin and Oligofructose Improve Sensory Quality and Increase the Probiotic Viable Count in Potentially Synbiotic Petit-Suisse Cheese. **LWT - Food Science and Technology,**v. 41, p. 1037–1046, 2008.

CLAEYS, W.L. et al. Raw or Heated Cow Milk Consumption : Review of Risks and Bene Fits.**Food Control,**v. 31, n. 1, p. 251–262, 2013.

CODEX ALIMENTARIUS COMMISION (CAC). Reported of the 27th session of the **Codex Committee on Nutrion And Foods for Special Dietary Uses**. Bonn, Germany, p. 21-25, 2005.

COLLINS, F. W. 1989. Oat phenolics: avenanthramides, novel substituted N-cinnamoylanthranilate alkaloids from oat groats and hulls. **Journal of Agricultural and Food Chemistry**, v. 37, n. 1, p. 60–66, 1989.

Comino, I.; Moreno, M. de L.; Sousa.C. Role of Oats in Celiac Disease.**World Journal of Gastroenterology**, v. 21, n. 41, p. 11825–11831, 2015.

COOK, G, C., AND S. K. KAJUBI. Tribal incidence of lactase deficiency in Uganda. **The Lancet,** v. 1, n. 7440, p. 725-729,1996.

DIMBERG, L. H. et al. Variation in Oat Groats Due to Variety, Storage and Heat Treatment. I: Phenolic Compounds. **Journal of Cereal Science**, v. 24, n. 3, p. 263–272, 1999.

DHINGRA, D. et al. Dietary fibre in foods: a review. **J Food Sci Technol,** n. 49, v. 3, p. 255–266, 2012.

DUTA, D.E.; CULETU, A. Evaluation of Rheological, Physicochemical, Thermal, Mechanical and Sensory Properties of Oat-Based Gluten Free Cookies.**Journal of Food Engineering,**v.162, p. 1–8, 2015.

ELORANTE, A-M. et al. Food Sources of Energy and Nutrients in Finnish Girls and Boys 6-8 Years of Age - the PANIC Study.**Food & Nutrition Research**, v. 1, p. 1–12, 2016.

ELLEUCH, M.et al. Dietary fibre and fibre-rich by-products of food processing: Characterisation, technological functionality and commercial applications: A review. **Food Chemistry**, v. 124, n. 2, p. 411-421, 2011.

ESMERINO, E.A. et al.The Influence of Sweeteners in Probiotic Petit Suisse Cheese in Concentrations Equivalent to that of Sucrose.**Journal of Dairy Science**, v. 96, n. 9. p. 5512–5521, 2013.

FERNANDES, C. F; SHAHANI, K. M.; AMER, M. A. Therapeutic Role of Dietary Lactobacilli and Lactobacillic Fermented Dairy Products.**Microbiology Reviews,** v. 46, p. 343–56, 1987.

FOOD AND DRUGS ADMINISTRATION (FDA). FDA Allows Whole Oat Foods to Make Health Claim on Reducing the Risk of Heart Disease.**Food and Drug Administration**, U.S. Depar, 1–6. USA. 1997.

FOOD AND DRUGS ADMINISTRATION (FDA). FDA: CFR - Code of Federal Regulations Title 21. **FOOD FOR HUMAN CONSUMPTION**,*vol. 2*, 2016. Disponível em: https://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfcfr/cfrsearch.cfm?fr=870.5225.

Acesso em: 21 de janeiro de 2018.

FOX, P. F. et al.Fundamentals of cheese science. Gaithersburg: Aspen, p. 544, 2000.

FULGONI, V.L. et al. ScienceDirect Oatmeal Consumption Is Associated with Better Diet Quality and Lower Body Mass Index in Adults : The National Health and Nutrition Examination Survey.**Nutrition Research,**v. 35, n. 12, p. 1052–1059, 2015.

FURLAN, L.G., DUARTE, U.L.; MAULER. R.S. Avaliação das propriedades de compósitos de polipropileno reforçados com casca de aveia.**Quim. Nova**, v. 35, n. 8, p. 1499–1501, 2012.

GAMEL, T.H. et al. Enzymatic Extraction of Beta-Glucan from Oat Bran Cereals and Oat Crackers and Optimization of Viscosity Measurement.**Journal of Cereal Science**, v. 59, n. 1, p. 33–40, 2014.

HEINI, R.L., et al.Sensory characteristics of wholegrain and bran-rich cereal foods – A review. **Trends in Food Science &Technology**, v. 47, p. 25-38, 2016.

HEYMAN, M.B. Lactose Intolerance in Infants, Children, and Adolescents. **Pediatrics**, v. 118, n. 3, p. 1279-1286, 2006.

HOLICK, M.F.; CHEN. T.C. Vitamin D Deficiency : A Worldwide Problem with Health.**The American Journal of Clinical Nutrition,** v. 87, p. 1080–86, 2008.

INSTITUTO BRASILEIRO DE GEOGRAFIA E ESTATÍSTICA – IBGE.Quantidade de Leite Cru Ou Resfriado Adquirido E Industrializado Pelo Estabelecimento, Segundo Os Meses - Brasil 4º Trimestre de 2016. 2016.

INSTITUTO BRASILEIRO DE GEOGRAFIA E ESTATÍSTICA – IBGE. Projeção da população do Brasil e das Unidades da Federação. Brasília: IBGE, 2016.

KIRK R.S.;SAWYER, R. Pearson’s compostion and analysis of foods, 9th edn. Addison-Wesley Longmam Inc., Harlow, England, p. 285, 1999.

KROGER, M.; MEISTER, K.; KAVA, R. Low-calorie Sweeteners and Other Sugar Substitutes: A Review of the Safety Issues . **Comprehensive Reviews in Food Science and Food Safety**, v. 5, n. 2, p. 35–47, 2006.

LADJEVARDI, Z.S. et al. Physicochemical Properties and Viability of Probiotic Bacteria of Functional Synbiotic Camel Yogurt Affected by Oat β - Glucan during Storage. **J. Agr. Sci. Tech.**,v. 18, p. 1233–1246, 2016.

LAUREATI, M. et al. Effect of fiber information on consumer’sexpectation and liking of wheat branenriched pasta. **Journal of Sensory Studies**,v. 31, p. 348–359, 2016.

LAZARIDOU, A.; BILIADERIS, C. G.; IZYDORCZYK, M.S. Molecular Size Effects on Rheological Properties of Oat Β -Glucans in Solution and Gels. **Food Hydrocolloids**,v. 17, p. 693–712, 2003.

LAZARIDOU, A. et al. Structure Development and acidification Kinetics in fermented milk containg oat b-glucan, a yogurt culture and probiotic strain.**Food Hydrocolloids**, v. 34, p. 204-214, 2014.

LIMA, M.S. De; Révillion, J.P.P.; Padula, A.D. Estratégias Competitivas E de Desenvolvimento de Produtos Lácteos Funcionais : Estudos de Caso Em Empresas Agroindustriais Da Região Sul Do Brasil.**Ciência Rural,**v. 39, n. 5, p. 1547–51, 2009.

MAIJALA, K. Cow Milk and Human Development and Well-Being.**Livestock Production Science** v. 65, p. 1–18, 2000.

MARUYAMA, L.Y.et al. Probiótico : influência de diferentes combinações de gomas. **Ciência E Tecnologia de Alimentos**, v. 26, n. 2, p. 386–393. 2006.

MATTOS, L.L., MARTINS, I.S. Dietary fiber consumption in an adult population. **Rev Saúde Púlica**, v. 34, n. 1, p. 50-55, 2000.

MEHTA, N. et al. Novel trends in development of dietary fiber rich meat products—a critical review. **J Food Sci Technol,**v. 52, n. 2, p. 633–647, 2013.

NAZIR, F.; SALIM, R.; BASHIR, M. Impact of wheat-oat blending on extensibility of dough.**Journal of Pharmacognosy and Phytochemistry,**v. 6, n. 6, p. 2074-2077, 2017.

NDOLO, V.U.; BETA, T. Distribution of Carotenoids in Endosperm, Germ, and Aleurone Fractions of Cereal Grain Kernels.**Food Chemistry**,v. 139, n. 1–4, p. 663–671, 2013.

OLIVEIRA, M.A.A.; OSÓRIO, M.M. Consumo de Leite de Vaca e Anemia Ferropriva na Infância Cow.**Journal de Pediatria**, v. 5, p. 361–367, 2005.

ORTIZ, Y.; GARCÍA-AMÉZQUITA, E.; ACOSTA, C.H. SEPÚLVEDA, D.R. Functional Dairy Products. In: Barbosa-Cánovas G. et al. (eds) **Global Food Security and Wellness**. Springer, New York, NY, 2017.

OZER, B.H.; OKIRMACI, H.A. Functional Milks and Dairy Beverages.**International Journal of Dairy Technology,** v.63, n. 1, p. 1–15, 2010.

PADALINO, L. et al. Formulation Optimization of Gluten-Free Functional Spaghetti Based on Maize Flour and Oat Bran Enriched in β-Glucans.**Materials,** *v.* 4, n. 12, p. 2119–2135, 2011.

PAPPALARDO, G.; LUSK. J.L. The Role of Beliefs in Purchasing Process of Functional Foods.**Food Quality and Preference**, v. 53, p. 151–158, 2016.

PEREIRA, G.A.P. et al.Dietary Calcium – Strategies to Optimize Intake. **Revista Brasileira Reumatológica,** v. 49, n. 2, 2009.

PETERSON, D.M. Oat Antioxidants.**Journal of Cereal Science,** v. 33, n. 2,p. 115–129, 2001.

PETERSSON, K. et al.The Effects of Cereal Additives in Low-Fat Sausages and Meatballs. Part 2: Rye Bran, Oat Bran and Barley Fibre.**Meat Science**, v. 96, n. 1., p. 503-508, 2014

PINTO-SÁNCHEZ, M.I. et al. Safety of adding oats to a gluten freediet for patients with celiac disease: systematic review and meta-analysis of clinical and observational studies. **Gastroenterology,** v.153, p. 395–409, 2017

PRUDENCIO, I.D. et al. Petit Suisse Manufactured with Cheese Whey Retentate and Application of Betalains and Anthocyanins.**LWT - Food Science and Technology,** v. 41,p. 905–910, 2008.

RAMÍREZ-SANTIAGO, C. et al.Viscoelastic Properties and Overall Sensory Acceptability of Reduced-Fat Petit-Suisse Cheese Made by Replacing Milk Fat with Complex Coacervate. **Dairy Science & Technology,** v.92, p. 383–398, 2012.

RASANE, P. et al. Nutritional advantages of oats and opportunities for its processing as value added foods - a review. **J Food Sci Technol,** v. 52, n. 2, p. 662–67, 2013

SANCHEZ-PARDO M.E.; JIMENEZ, G.; GONZALIC-GRACIA, I. Study aboutthe addition of chemically modified starches (cross-linked cornstarches), dextrins, and oat fibers in pound cake. Special Abstracts. **J Biotechnol**, v. 150, p. 316–319, 2010.

SILEMG. 2017. Consumo de Leite No Brasil Ainda Está Aquém Da Quantidade Recomendada Pelo Ministério Da Saúde. Disponível em: https://www.milkpoint.com.br/cadeia-do-leite/giro-lacteo/consumo-de-leite-no-brasi ainda-esta-aquem-da-quantidade-recomendada-pelo-ministerio-da-saude-84030n.aspx.

SALGUEIRO, J. et al. Determination of relative bioavailability of zinc in a petit suisse cheese using weight gain and bone zinc content in rats as markers. **Biological Trace Element Research**, v. 104, n. 3, p. 261–226, 2005.

SALGUEIRO, J. Normal growth rate in rats is recovered after a period of zinc deficiency by restoration of zinc supply by means of a zinc-fortified Petit Suisse cheese. **Biological Trace Element Research,** v. 104, n. 3, p. 269–273, 2005.

SANTOS, T.S.S. “Petit Suisse” Cheese from Kefir : An Alternative Dessert with Microrganisms of Probiotic Activity.**Ciência E Tecnologia de Alimentos,**v. 32, n. 3, p. 485–491, 2012.

SHANKAR, P. ; AHUJA, S.; SRIRAM, K. Non-nutritive sweeteners: Review and update. Nutrition, v. 19, n.11-12, p.1293-1299, 2013.

SMITHERS, G.W. Whey and Whey Proteins — From ‘ Gutter-to-Gold.**International Dairy Journal,** v.18, p. 695–704, 2008.

SOUZA, V.R., et al. Analysis of various sweeteners in petit suisse cheese: determination of the ideal and equivalent sweetness. **Journal of Sensory Studies**, v. 26, n. 5, p. 339-345, 2011.

SOUZA, M.C.P. de, et al.Pure Oats as Part of the Canadian Gluten-Free Diet in Celiac

Disease: The Need to Revisit the Issue. **Canadian Journal of Gastroenterology and Hepatology**, p.1-8, 2016

STONE, H.; SIDEL, J. L. **Sensory Evaluation Practices**. Edited by Elsevier Academic. 3th ed. Amsterdam. 1985.

STRYCHAR, R. 2011. Oat: chemistry and technology. Edited by Canada Francis H. Webster, Francis Webster & Associates, Branson, Missouri, U.S.A. and Peter J. Wood, Guelph Food Research Centre, Guelph, Ontario. 2nd ed. Vancounver: Ag Commodity Research, Vancouver, British Columbia, Canada.

TAPSAS, D., et al. Swedish children with celiac disease comply well with a gluten-free diet, and most include oats without reporting any adverse effects: a long-term follow-up study. Nutrition Research, v. 34, n. 5, p. 436-441, 2014

TSOPMO, A. Processing and Impact on Active Components in Food. Processing and Impact on Active Components in Food. Ottawa: Elsevier. 2015.

VIEILLE, SEBASTIEN La, et al. Celiac Disease and Gluten-Free Oats : ACanadianPosition Based on a Literature Review Celiac Disease and Gluten-Free Oats : A Canadian Position Based on a Literature Review.**Canadian Journal of Gastroenterology and Hepatology**, p. 1–10.2016.

VILLARREAL, M.L.M.,et al. Advantageous Direct Quantification of Viable Closely Related Probiotics in Petit-Suisse Cheeses under In Vitro Gastrointestinal Conditions by Propidium Monoazide - qPCR.**Plos One**, v. 8, n. 12, p. 1–11, 2013.

VILELA, D. et al. A evolução do leite no Brasil em cinco décadas. **Revista de Política Agrícola**, v. 1, p. 5-24, 2017.

WALTERS, M. et al. Phenolic acids, avenanthramides andantioxidant activity of oats defatted with hexane or supercritical fluid. **Journal of Cereal Science,**v. 79, p. 21-26, 2018.

WAKELING, I.N.; HALLIDAY, J.H. MacFie. Designing consumer trials balanced for first and higher orders of carry-over effect when only a subset of samples from t may be tested.**Food Quality and Preference,**v. 3293, n. 95, p. 299–308, 1995.

YUHARA, T.T.; Matsubara, S.T.; Garcia, S. Production of Functional Quark Cheese Containing Exopolysaccharides.**Rev. Inst. Laticínios Cândido Tostes**, v. 69, n. 6, p. 387–394, 2014.

SEGUNDA PARTE – Artigos

Artigo 1:Influence of oat bran addition in on technological properties and nutritional enhance of petit Suisse

Será submetido á LWT – Food Science and Techonology, sendo apresentado de acordo com as regras de publicação dessa revista.

Ana Paula Lima Ribeiro[a], Michel Cardoso de Angelis Pereira[a], Luiz Ronaldo de Abreu[a], Sandra Maria Pinto[a]

a Department of Food Science, Federal University of Lavras, 37200-000, Lavras, MG, Brazil

*Corresponding author: Ana Paula Lima Ribeiro, Department of Food Science, Federal University of Lavras, UFLA, CEP 37200-000 Lavras, MG, Brazil. Tel.:+55 35 3829-1024. E-mail address: anaplima.com@gmail.com

ABSTRACT

Petit suisse is a cheese, with a smooth and sweet taste. Currently, the petit suisse market is very focused on children. However, petit suisse is a great dairy product that should be consumed by all ages, which makes it necessary to increase research in this area. Oats is a cereal rich in protein, minerals, in addition to antioxidants. It is very consumed by high fiber content. When consumed regularly, it is able to diminish from many diseases. In addition, oats have many industrial applications because of their high water holding capacity and gel formation. The objective of the study was to 1) include oat bran in petit suisse to increase the amount of nutrients and dietary fiber of this food in order to meet the needs of a young and adult population 2) to take advantage of oat gelling capacity to decrease the syneresis of petit suisse with whey retentate and consequently increase the shelf life of the product. The petit suisse samples were manufactured with 2 different concentrations of thickeners (1 and 2%) and 3 different amounts of oat bran (3%, 6% and 9%), totaling 6 treatments and two controls which contained only 1% or 2% thickener and did not have oats. Chemical analysis, syneresis, water holding capacity, instrumental texture profile, rheology, fermentation time and water activity were performed. The results indicated that the addition of petit suisse oats provided a nutritional increase due to the addition of fiber and beta glucan. The results of syneresis and water retention capacity decreased with the addition of oats. The increase of oats promoted a decrease in water activity and there was no difference between the treatments in the fermentation time. The results showed that the use of oats in petit suisse is an alternative that brings nutritional benefits to the consumer and technological to the company

Keywords: Cheese. Whey. Cereal. Syneresis.

Introduction

The consumption of dairy products has greatly increased in recent decades and is mainly driven by technological advances in the dairy industry (Santos et al 2017). Petit suisse is a type of French cheese very popular in many countries. This dairy product is unripened, unsalted, smooth and creamy cheese, characteristics that make this product to be similar a thick yogurt (Esmerino et al. 2015). Besides, the high nutrional value makes this cheese even more attractive, once it is rich in calcium, phosphorus and fat-soluble vitamins, proteins, coupled to excellent digestion (Barros and Delfino 2014). Although this is a cheese, it is largely consumed as a dessert, and strawberry is the most popular flavor in the literature (Cardarelli et al. 2008; Esmerino et al. 2013; Pereira et al. 2016; Souza et al. 2011). Because of it consistency is very soft cream cheese and has a delicate sweet flavor, this cheese is very consumed mainly for children (Prudencio et al. 2008), although it is very suitable for all ages. The critical step in petit suisse preparation is the separation of the curd from the cheese whey, particularly due to the microbiological risk (Santos et al. 2012). The whey released by this cheese is considered a residue for food industry and very difficult to be eliminated. When it is disposed in rivers, lakes or open fields causes serious ambiental problems (Gajendragadkar and Gogate 2016). The high content of the water-soluble components (lactose, fats, salts, and proteins) presents in cheese whey, results in high Biological Oxygen Demand (BOD) and chemical oxygen demand (COD) (Brandelli, Daroit, and Corrêa 2015; Singh, Singh, and Imam 2014). For this reason, many researchers concentrated in to find value-added products from these dairy industry wastes (Ferreira-Pinto et al. 2017). To avoid generating residues, the use of thickeners has been increased to maintain the whey in the curd producing petit suisse with whey retentate.

The use and comsumption of oat has increasedsince consumers are aware of oat health benefits. The incorporation of oat has been used to improve nutritional and industrial quality of foodstuff (Rasane et al., 2013). Oat bran is the outermost edible layer of the oatmeal. This bran is very popular because of the high amount of dietary fibers (Khalil et al. 2015), in whichβ-glucan is the most important soluble fiber of this cereal.A diet rich in dietary fibers is able to reduces postprandial glycaemic responses (Steinert, Raederstorff and Wolever, 2016; Wolever et al., 2018), reduces serum cholesterol and overweight (Whiteheadet al., 2014). The consume of oat fibers is also associated to promotion of normal laxatation, reduce of cardiovascular disease, cancer and diabete (Ramírez-Santiago et al. 2012). Thus, oat bran incorporated into milk products is an alternative to increase fibers consumption.

Besides, oat bran is able to improve technologic characteristics of processed food products, such as the texture, water holding capacity, emulsification sensory characteristics and shelf-life of food products (Mudgil and Barak 2013; Chawla and Patil 2010). It also has desirable rheological characteristics, such as increased viscosity and gelling properties (Petersson et al., 2014, Lazaridou et al, 2014). In addition, the main soluble fiber of oat bran, β-glucans, has a great capacity to form viscous solution at low concentrations (Wood, 2007). The use of oats becomes suitable for dairy products that need firmness throughout the shelf life. With the aim of satisfying consumers, manufacturers pursue innovative products that meet consumers' expectation. Thus the nutritional and technological characteristics of oat bran are very suitable ingredient for milk products.

The aim of this study is 1) to include oat bran in petit suisse cheese to increase the amount of dietary fiber of this cheese in order to meet the needs of consumers and 2) to take advantage of oat bran gelling ability to decrease the syneresis of petit suisse cheese whey retentate to increase the product shelf life

Materials

The following is a list of materials used in the food preparations in this study: skimmed milk (0.0% w/w),rennet (HA-LA®) mesophilic culture *lactococcus lactis* ssp. *lactis and lactococcus lactis* ssp. *cremoris* (Chr. Hansen), sucrose (União, Tarumã, SP, Brazil), commercial oat bran (Quaker Oat Bran™) with 0.8grams of beta glucan per 10grams of oat as specified by the supplier, thickener Estabgem 071 (Gemacon Tech Juíz de Fora, MG, Brazil).

Manufacture of petit suisse cheeses

The petit suisses cheeses with different concentrations of oat and thickeners were manufactured (Table 1). Milk previously skimmed (0.0%) was mixed with sugar (10%), oat bran, thickener and heat treatmento at 85°C/30 min and cooled to 35°C. Mesophilic culture (L. lactis ssp. *lactis* and L. lactis ssp. *cremoris*) and rennet was added in the proportion of 0.5mL per 1L of milk and 10% of what has been recommended by the manufacturer, respectiveley. The ingredients were mixture and fermented for an average of 14-16h hours until reach pH 5.6. The curd was broken up and shaken for 5 minutes. No study reported the addition of oat in petit suisse cheese. Thus, it was necessary to perform preliminary experiments based on researches on milk cereal beverages and the recommended daily intake of β-glucan soluble fibers (0.75g per portion) by FDA (2016). Petit Suisse was storage to 4°C for further analysis.

Table1. Proportion (%) of thickeners and oat bran used in different formulations petit suisse cheese with whey retention

	Membership in the formulation	
Treatments (Formulations)	Oat (%)	Thickener (%)
C1	-	1
T1	3%	1
T2	6%	1
T3	9%	1
C2	-	2
T4	3%	2
T5	6%	2
T6	9%	2

Chemical characterization of petit suisse cheeses

The nine samples of petit suisse cheeses were evaluated according to the following methods for total protein content by the Kjeldahl method (AOAC, 2006) moisture by oven drying method (AOAC, 1995) and fat by the Soxhlet method (AOAC, 1995) and ash (AOAC, 2006).

Total dietary fiber

The analyse of total dietary fiber was performed following the official method of AOAC 985.29 (2005). The samples was previously dryed and the enzymatic-gravimetric method was carried out using thekit Sigma-Aldrich DF-100A y TDF-C10. Phosphate buffer was added to the samples and enzymatic digestions were performed, starting with the addition of α-amylase, protease and finally amyloglucosidase. To promote soluble fiber preciptation, ethanol were added and the samples werre filtered. The residue was washed with 78% EtOH, 95% EtOH and acetone, then dried and weighed. Ash and protein of the samples was determined by Kjeldahl method (AOAC, 2006) and gravimetry methdos (AOAC, 2006), respecitvely. To value of the dry filtration residue is subtracted from the ash and protein value.

Syneresis of petit suisse samples

The measure of syneresis in petit suisse was determined according to (Riener et al. 2010). Samples of each petit suisse was weighted (30g) and spread on a Whatman No.1 filter paper (Whatman, Sigma-Aldrich) in a funnel placed on the top of a 50mL graduated cylinder. The graduated cylinder was kept at 4°C for 8 h and the volume of the liquid was registered for using in the following equation (1):

Syneresis = [(Weight of whey after filtration / Weight petit Suisse sample)] x 100 (1)

Water holding capacity (WHC)

The water-holding capacities was determined according to (Inglett et al. 2014). The amount of 2g of each oat samples were mixed with distilled water to complete 30g and vigorously mixed using a vortex for 1 min a homogenous suspension and then held for 2 h, followed by centrifugation at 1590 × *g* for 10 min. Each treatment was replicated three times. Water-holding capacity was calculated by the following equation (2):

$$\text{Water holding capacity (g/100g)} = \frac{\text{water add (g)} - \text{decanted water (g)}}{\text{dry sample weight(g)}} * 100 \qquad (2)$$

Instrumental texture profile

The texture analysis of the different treatments was conducted in a model texturometer Stable Micro Systems TA-XT2i Model (Goldaming, England). Before the start-up test, the samples were stored under refrigeration in B.O.D. at 4°C. The characteristics of the probe were cylindrical stainless steel tube of 20 mm, cylindrical aluminum, with contact area of 314 mm^2. The conditions of analysis were as follows: sample height 3cm, 30% in the compression ratio the height of the sample under trigger 5g, penetration distance of 35 mm, probe velocity during penetration of 1 $mm.s^{-1}$, probe velocity before penetration of 1 mm s-1 and probe velocity after penetration of 1 $mm.s^{-1}$. All data were analyzed using the software Exponent Lite Express (Stable Micro Systems, Godalming, UK). The analyzed parameters were: hardness, adhesiveness, cohesiveness and chewiness.

Rheological properties

The rheological test of petit suisse were performed at 4°C using the HAAKE Rheostress 6000 rheometer (ThermoScientific, Karlsruhe, Germany), equipped with HAAKE A10 thermostatic bath (ThermoScientific) and a universal temperature control system HAAKE UTM Controller (ThermoScientific), coupled to a set of parallel plate geometry sensors (34.997 mm in diameter) with a gap of 1.0. In the measurements, a volume of approximately 1 mL was used for each sample.

To eliminate thixotropy (the influence of time on the flow behavior of the treatments), each sample was subjected to a continuous strain rate ramp in the range of 0 to 300 s-1, for 2 minutes for the rising curve and 2 minutes for the downward curve. After this procedure, the flow curve was generated for the rheological characterization of each sample by applying a flow curve varying the rate from 0 to 300 s-1 for 3 minutes. Newton's Law (Eq. 3), Power Law (Eq. 4) and Herschell-Buckley (Eq. 5) models were fitted to the experimental data of the flow curves.

$$\sigma = \mu\dot{\gamma} \quad (3)$$

$$\sigma = K\dot{\gamma}^{n} \quad (4)$$

$$\sigma = \sigma_0 + K\dot{\gamma}^{n} \quad (5)$$

Where σ is the shear stress (Pa), μ is the Newtonian viscosity (Pa • s), is the strain rate (s-1), K is the consistency index (Pa • sn), n is the flow behavior index (dimensionless), and σo is the yield stress (Pa).

Water activity

Analyses of water activity were performed (Aqualab, 3-TE model, Decagon Devices Inc., Pullman, WA, USA). The amount of 10 g of samples was placed in plastic containers and the controlled standard temperature of 25° C ± 1° C.

Fermentation time

A laboratory stove was used in the temperature of 32**°C,** since it is the appropriated temperature for the lactic culture used in this study. The petit Suisse was placed in the laboratory stove and the pH was measured one hour at a time until reach the pH of 4.3. The pH readings were noted to compare the difference in fermentation time between treatments.

Statistical analysis

A full factorial with 9 treatments was performed and analyzed in triplicate. Physical and physicochemical analyses (protein, fat, syneresis, rheology and texture profile of cheeses) was evaluated. Scott Knott test was used in order to determine differences between the means. Petit Suisse formulated only 2% of thickener and not added oat served as the control 2 (C2) and maintained similar texture to those commercial petit suisse with thickener added. The control 1 (C1) was used to compare samples that was formulated with only 1% of thickener. The significance was determined at P ≤0.05. Data analysis was performed using SISVAR software.

Results

Table2. Effect of incorporation of different levels of oat bran on the chemical characterization of petit suisse cheeses in the whole matter

Attributes	Treatments							
	C1	T1	T2	T3	C2	T4	T5	T6
Moisture	51±0.4[a]	88.62±0.3[a]	87.89±0.4[a]	87.47±0.2[a]	87.91±0.4[a]	85.98±0.2[a]	85.31±0.4[a]	84.93±0.5[a]
Protein	9.46±0.3[a]	9,40±0.2[a]	9.06±0.3[a]	8.96±0.4[a]	12.05±0.3[b]	12.02±0.4[b]	11.84±0.1[b]	11.45±0.1[b]
Total Dietary Fiber	0.0 [a]	1.45±1.2 [a]	2.03±1.4[b]	2.54±1.8[d]	0.0 [a]	1.66±1.5[a]	2.13±1.8[c]	2.65±1.1[d]
Soluble Fiber	0.0 [a]	1.03±0.8 [a]	1.32±1.2[b]	1.68±1.3d	0.0 [a]	1.1±1.4 [a]	1.53±0.9[c]	1.84±1.2[d]
Insoluble Fiber	0.0 [a]	0.42±1.0 [a]	0.71±1.4 [a]	0.9±1.3 [b]	0.0 [a]	0.56+1.5 [a]	0.6±1.2 [a]	0.8±1.2 [b]
Fat	0.0 [a]	0.4±0.1 [a]	0.9±0.3[b]	0.9±0.3 [b]	0.0 [a]	0.27±0.4 [a]	0.65±0.3[b]	0.9±0.2 [b]
Ash	0.03±0.1[a]	0.04±0.01[a]	0.12±0.01[b]	0.13±0.01[b]	0.04±0.01[a]	0.06±0.01[b]	0.07±0.01[b]	0.07±0.01[b]

C1= 1% thickener, C2 = 2% thickener , T1 = 1% thickener + 3% oat bran, T2= 1% thickener + 6% oat bran, T3= 1% thickener + 9% oat bran, T4 = 2% thickener + 3% oat bran, T5 = 2% thickener + 6% oat bran, T6 = 2% thickener + 9% oat bran. Means bearing at least one common superscript in the same storage time do not differ significantly (p>0.05) at Scott Knott test in the whole matter.Values are expressed as means ± *SD* from three replications.

The results of chemical characterization of petit suisse cheeses are illustrated at table 2.The moisture of the samples did not present significantly difference (p>0.05), it was observed an increase of protein in the treatments with 2% of thickener, and an increase of fat in the treatments with 6 and 9% of oat (T2, T3, T5 and T6).

According to Brazilian law, petit Suisse is a cheese with high moisture (>55%) that can be added non-dairy up to a maximum of 30%. The moisture and the addition of non dairy ingredients are in accordance with the law. Those characteristics are essential to make this cheesevery soft cream. The significantly ($p \leq 0.05$) high amount of protein in treatment with 2% of thickener (C2, T4, T5 and T6) is mainly to the thickeners properties, although Chen et al. (1988) showed that oat bran is also a good source of protein, and may contain an average of 5.54%. Related to fat, oat is one of the cereal that contain higher levels of lipid compared to other cereal grains and it is excellent sources of energy and unsaturated fatty acids. The higher concentrations of lipids are stored close to the endosperm and can vary 2.5-11.8% according to variety and extraction methods (Zhou et *al*. 1999). Thus, the treatment with higher amount of oat bran, presented also higher amount of lipids, but not to high compared to oat kernel since lipids are most concentrated in the endosperm and not in the bran.

Dietary Fiber

Table 3. Effect of incorporation of different levels of oat bran on dietary fiber characterization of petit suisse cheeses on the dry basis matter.

	Treatments							
Dietary Fiber	C1	T1	T2	T3	C2	T4	T5	T6
Total DietaryFiber	0±0[a]	4,15±0.37[b]	8,78±0.43[e]	13,07±0.59[g]	±0[a]	4,84±0.36[c]	7,96±0.43[d]	11,97±0.59[f]
Soluble fiber	0±0[a]	0.45±0.1[a]	1.66±0.7[c]	3.03±0.08[d]	±0[a]	0.43±0.1[a]	1.25±0.22[b]	2.39±0.08[d]
Insoluble Fiber	0±0[a]	3.7±0.38[b]	7.12±0.22[e]	10.04±0.67[f]	±0[a]	4.42±0.38[c]	6.71±0.23[d]	8.77±0.68[g]

C1= 1% thickener, C2 = 2% thickener , T1 = 1% thickener + 3% oat bran, T2= 1% thickener + 6% oat bran, T3= 1% thickener + 9% oat bran, T4 = 2% thickener + 3% oat bran, T5 = 2% thickener + 6% oat bran, T6 = 2% thickener + 9% oat bran. Means bearing at least one common superscript in the same storage time do not differ significantly ($p>0.05$) at Scott Knott test in the dry basis matter. Values are expressed as means ± *SD* from three replications.

The table 3 shows the amount of dietary fibers in each treatment of petit Suisse cheese. The results showed that the treatments that had higher amount of oat bran (T2, T3, T5 and T6) also had significantly ($p \leq 0.05$) higher amount of total dietary fiber, in which the treatments with 9% of oat bran (T3 and T6) presented significantly ($p \leq 0.05$) higher values of soluble and insoluble fibers. This result was expected since oat bran is a cereal rich in fibers.Although Milk and Milk products are good source of calcium, vitamins and proteins, it is not a good source of fiber content, as can be seen in the controls C1 and C2, that did not presented dietary fiber. All the treatments that had fiber in the composition presented soluble and insoluble fibers, and the content of insoluble fibers was higher compared to soluble fibers for all treaments. The T3 and T6 presented higher amount of total dietary fibers, since it also had great amount of oat bran added.Oat bran was selected since it has high fiber content (Khalil et al. 2015) compared to oat kernel and oat flour. Besides, Zhang et al. (2011) showed that soluble dietary fiber in bran is up to 14.2%. Oat is one of few cereals that present soluble fibers, being the most important fiber of oat bran the β-glucan. The results are in accordance with AlHasawi et al. (2017) that showed that oat bran has amount of insoluble fibers greater than soluble fibers, and the main soluble fiber is β-glucan, that can be up to 6.6% of the bran in wet weight.Aleixandreand Miguel (2016) and Stephen et al. (2017) reinforcedthat the consumption of β-glucan is related to a very positive effect on perceptions of satiety, reduction in plasma cholesterol and weight loss. Besides, Ladjevardi et al. (2016) stated that β-glucan present in oat bran soluble fiber acts like a prebiotics, improving intestinal microorganism activity and increase their survival, which make this cereal very appropriated for dairy products. Dhingra et al. (2012) concluded that dietary fiber holds all the characteristics required to be considered as an important ingredient in the formulation of functional foods, due to its beneficial health effects. Thus, oat bran and petit suisse turns a good source of dietary fibers mainly for milk product consumers.

Table 4. Syneresis of petit Suisse chesse with oat bran measured over the time

	Storage Period (weeks)				
Samples	1	2	3	4	5
C1	28.76±0.55[a]	27.55±1.86[a]	30.09±1.49[a]	41.84±1.74[a]	34.92±2.54[b]
T1	22.42±0.25[b]	25.32±1.27[a]	22.23±2.22[b]	35.16±0.2[b]	47.68±1.94[a]
T2	18.84±0.53[c]	14.57±0.36[c]	14.49±0.22[c]	19.99±1.25[d]	17.60±1.25[e]
T3	13.54±1.43[d]	13.23±2.44[c]	11.33±1.57[d]	17.44±1.29[e]	14.32±1.06[f]
C2	23.39±0.70[b]	18.07±1.62[b]	19.90±1.81[b]	29.31±1.74[c]	25.34±0.68[c]
T4	14.50±1.45[d]	13.18±1.48[c]	13.80±2.02[c]	16.95±0.21[e]	20.92±1.88[d]
T5	11.89±1.27[e]	10.46±0.07[d]	8.98±1.06[d]	14.31±0.55[f]	8.85±0.96[g]
T6	9.99±0.67[f]	7.67±0.45[e]	8.6±1.5[d]	13.66±1.4[f]	7.42±0.16[g]

C1= 1% thickener, C2 = 2% thickener , T1 = 1% thickener + 3% oat bran, T2= 1% thickener + 6% oat bran, T3= 1% thickener + 9% oat bran, T4 = 2% thickener + 3% oat bran, T5 = 2% thickener + 6% oat bran, T6 = 2% thickener + 9% oat bran. Means bearing at least one common superscript in the same storage time do not differ significantly (p>0.05) at Scott Knott test. Values are expressed as means ± *SD* from three replications.

The table 4 shows the result for syneresis of petit Suisse with oat bran measured over the time**.**Instead T3, all treatments with only 1% of thickener (C1, T1 and T2) presented syneresis higher than the C2, which is undesirable. However, the syneresis decreased according to the amount of oat bran increase for all treatments. For our surprise, when it was added 1% of thickener and 9% of oat (T3), did not present difference (p>0.05) of the treatments that had 2% of thickener (T4, T5 and T6).

Despite the use of thickener to try to retain the cheese whey, syneresis is observed in the control sample (C2) over 4 weeks. This finding showed thatthe use of oat bran is able to act like a thickener to decrease the syneresis of petit Suisse and to keep petit Suisse with whey retentate texture longer. The fiding is in accordance with Ozcan and Kurtuldu (2014), who showed the decrease in syneresis of yogurt added with oat bran compared to the control. Singh et al.(2014) stated that whey is one of the major effluents and source of BOD in wasterwater in the food industry, then the diminish in syneresis represents an important technological improvement, since it avoids to produce whey.According to Lazaridou et al.(2003), this behavior is explained by the water holding capacity of oat fibers. Oat has b-glucan, a soluble fiber that can impart high viscosity to aqueous solutions due to its high molecular weight, conformation and interactive properties.For this reason, the use of oat bran in petit Suisse with whey retentate is able to decrease the syneresis and the amount of thickeners to be used.

Table5. The water holding capacity (WHC) of petit suise with whey retentate with different amount of thickeners (1% and 2%) and oat bran (3%, 6% and 9%).

Samples	Water holding Capacity (g/100)
C1	193.06± 1.58 ^{a}
T1	203.06± 1.92^{b}
T2	289.66± 1.07^{e}
T3	336.67± 3.46^{f}
C2	223.93 ± 0.89^{c}
T4	239.14 ± 2.14^{d}
T5	341.63 ± 0.37^{g}
T6	376.77± 2.3^{h}

C1= 1% thickener, C2 = 2% thickener , T1 = 1% thickener + 3% oat bran, T2= 1% thickener + 6% oat bran, T3= 1% thickener + 9% oat bran, T4 = 2% thickener + 3% oat bran, T5 = 2% thickener + 6% oat bran, T6 = 2% thickener + 9% oat bran.Means bearing at least one common superscript do not differ significantly (p>0.05) at Scott Knott test.Values are expressed as means $\pm$ *SD* from three replications.

Table 5 shows clearly, the water holding capacity (WHC) increase as increase the amount of oat bran and thickeners. of T4 was not significantly different of the control($p>0.05$). The samples T4, T5 and T6 showed water holding capacity, significantly higher than C2 ($p\leq0.05$). It was surprinsingly that sample T2 and T3 had also great WHC than C2 and T4. The samples with The findings showed that the great water holding capacity of 9% of oat bran allowed to use only half of the amount of thickeners used in the control C2.

The addition of oat bran in petit suisse cheese increase the whey retentante in the curd due to the great water holding capacity of this cereal. This findings are aligned with Güler-Akın, Ferliarslan and Akın (2016) who showed that the increase in oat bran fibers in yogurt resulted in increase of WHC.

Liu et *al*. (2015) andBorchaniet *al.*(2016) linked the WHC of oat bran due to beta glucan. The findings of great water hold capacity of 9% of oat bran in food products are in according to Reddy et al. (2017). This results was expected, since oat bran is rich in dietary fibers, substances consisted by polysaccharide strongly hydrophilic. According to Mudgil and Barak (2013), the water is held on the hydrophilic sites of the fiber itself or within void spaces in the molecular structure. Zhu (2017) stated that oat is also rich in starch, which might also explain the great WHC behavior. Nedeljković et al. (2017) explained that oat bran is not considered a true bran, since it has high amount of starch compared to the aleurone that is mainly composed by fibers. Besides, oat has a great advantage over other cereals. Majzoobi et al. (2014) showed that oat in comparison with other cereal, i.e. wheat, are less susceptible to retrogradation when it is cooled. Majzoobi et *al.*(2014) concluded that the high amount of lipids in oat starch may be responsible for alters physicochemical properties, such as less retrogradation, which make this cereal very appropriated to be used in petit suisse cheese.

Table 6.Texture properties of petit suisse added with oat bran and different concentration of petit Suisse thickeners.

Samples	TPA parameters			
	Hardness	Cheweness	Adhesivene	Cohesivene
C1	18.05±0.9^{a}	13.12±0.7^{a}	-11.30±0.6^{a}	0.48±0.7^{a}
T1	26.00±0.2^{c}	15.24±0.3^{c}	-55.86±0.5^{c}	0.54±0.7^{c}
T2	29.70±0.8^{d}	16.05±0.7^{d}	-77.76±0.8^{d}	0.57±0.3^{d}
T3	33.80±0.8^{e}	22.35±0.3^{f}	-102.93±1.0^{e}	0.60±0.9^{e}
C2	23.59±0.3^{b}	14.28±0.7^{b}	42.69±0.9^{b}	0.50±09^{b}
T4	34.30±0.4^{f}	20.54±0.4^{f}	-115.88±0.8^{f}	0.59±0.9^{e}
T5	34.43±0.2^{f}	21.12±0.7^{e}	-117.57±0.9^{f}	0.60±0.5^{e}
T6	35.72±0.6^{g}	27.25±0.4^{g}	-120±1.0^{g}	0.61±0.7^{e}

C1= 1% thickener, C2 = 2% thickener , T1 = 1% thickener + 3% oat bran, T2= 1% thickener + 6% oat bran, T3= 1% thickener + 9% oat bran, T4 = 2% thickener + 3% oat bran, T5 = 2% thickener + 6% oat bran, T6 = 2% thickener + 9% oat bran.Means bearing at least one common superscript in the same collum do not differ significantly (p>0.05) at Scott Knott test.Values are expressed as means ± *SD* from three replications.

The evaluation of instrumental texture profile was presented in the table 6 and clearly shows significant difference in textural properties ($p \leq 0.05$) when increase the amount of oat bran in petit suisse. Considering petit suisse has smooth characteristic, it is desirable that the addition of oat bran keep the same firmness characteristic as the C2. Hardness, chewiness, cohesivene and adhesivene increased (in module) as increase the amount of oat bran in the samples. All samples added with oat bran presented higher TPA results ($p \leq 0.05$) of T7 and T8. The result showed that oat bran changed the product characteristics, as can be seen in the discussion.

The findings showed an increased of values for hardness, chewiness, cohesivene and adhesivene. The increase of those parameter in milk products is generally to the increase in proteins and fat. As all samples of the petit Suisse cheese were prepared with skimmed milk, this behaviourmight be explained by the rich amount dietary fibers, presented in oat bran. This result is accordance with Ningtyas et al. (2018), who found increase in values of texture parameters when added the soluble fiber oat beta glucan in cream cheese. Gelroth and Ranhotra(2001) and Ningtyas et al. (2018) stated thatβ-glucan presented in oat is used as a fat replacer to improve sensory characteristics of food product. The use of beta glucan as a fat replacer was also studied by Sarteshniz et al. (2017) and Sarteshniziet al.(2015) in meat products, but still has a lack of study in milk products.Huges et al. (1997) stated that oat is a good ingredient to be used as a attempt to offset the low level of fat.According to Paula et al. (2017) and Brennan and Cleary (2005), increase of texture parameters depends on β-glucan concentration and molecular weight of each oat cultivar, characteristics influenced by genetic background of the cereal, yield parameters and processing methods.Petersson et al. (2014) stated that the higher molecular weight of beta glucan is responsible for the ability of oat bran to create a gel easily than other cereal, i.e barleyβ-glucan.Acconrding to Ahmad et al. (2012) oat is suitable functional properties such as thickening, stabilizing, emulsification, and gelation.Mudgil and Barak(2013) concluded that the huge interest in oat is to the incorporation of β-glucan, a soluble fiber that when incorpored in low fat milk products improve the mouthfeel, scoopability or spoonability and sensory properties compared to those of full fat products.

Reology

Among the models used to describe the rheological behavior of petit suisse, the Power Law provided the best statistical parameters for the adjustment of the experimental data, with adequate values of coefficient of determination (R²) and mean square error (RMSE). The consistency index (K) determined by Power Law model were significant (p <0.05) among all the treatments tested (Table 7).

Table7. Rheological parameters obtained for petit suisse cheeses with 1% and 2% of thickener and different concentrations of oat bran (3%, 6% and 9%) measured over 5 weeks.

Treatment	Time	Power Law (PL)			
		K	***N***	**$RMSE_{PL}$**	**R^2_{PL}**
C1	0	4.9486 (±0.4993)	0.3780 (±0.0058)	0.7105	0.9940
	1	5.2765 (±0.4172)	0.3705 (±0.0065)	0.5545	0.9965
	2	6.1142 (±0.2680)	0.3674 (±0.0054)	0.5201	0.9975
	3	5.9012 (±0.5777)	0.3673 (±0.0058)	0.6698	0.9957
	4	5.5726 (±0.5500)	0.3808 (±0.0126)	0.5821	0.9971
R^2_{REG}					
***P* > F**					
		K	***N***	**$RMSE_{PL}$**	**R^2_{PL}**
T1	0	11.6473 (±0.3139)	0.39 97 (±0.0033)	2.7540	0.9877
	1	18.6951 (±0.6780)	0.34 74 (±0.0099)	2.6332	0.9916
	2	18.6160 (±4.8672)	0.34 18 (±0.0361)	2.9668	0.9639
	3	14.1740 (±1.6560)	0.36 88 (±0.0064)	3.6247	0.9788
	4	12.6732 (±2.9518)	0.37 88 (±0.0193)	1.2795	0.9490
R^2_{REG}					
***P* > F**					
		K	***N***	**$RMSE_{PL}$**	**R^2_{PL}**
T2	0	28.5 401 (±7.5389)	0.26 70 (±0.0071)	2.3537	0.9883
	1	39.4 809 (±5.2060)	0.24 19 (±0.0070)	2.4215	0.9500
	2	40.5854 (±6.3019)	0.30 24 (±0.0167)	4.5217	0.9636
		30.0714	0.32	2.5635	0.9955

	Time	K	N	RMSE_PL	R^2_{PL}
	3	(±1.0140)	42 (±0.0052)		
	4	35.5377 (±3.6421)	0.3185 (±0.0053)	1.4864	0.9697
R^2_{REG}					
P > F					
		K	***N***	**RMSE_PL**	**R^2_{PL}**
T3	0	56.6974 (±2.7903)	0.3241 (±0.0003)	4.5273	0.9784
	1	75.0421 (±0.1878)	0.2921 (±0.0004)	1.9246	0.9954
	2	90.0781 (±1.9904)	0.2821 (±0.0066)	2.5168	0.9823
	3	82.5749 (±3.4804)	0.2955 (±0.0111)	2.7810	0.9916
	4	78.6470 (±3.9118)	0.3334 (±0.0043)	4.4425	0.9842
R^2_{REG}					
P > F					

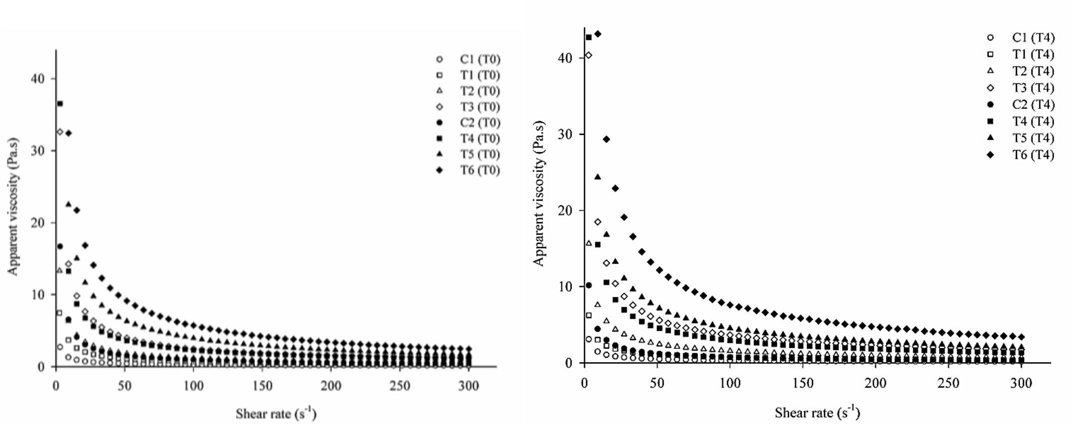
Treatment	**Time**	**Power Law (PL)**			
		K	***N***	**RMSE_PL**	**R^2_{PL}**
C2	0	20.5946 (±0.1955)	0.3842 (±0.0108)	4.4557	0.9721
	1	31.8078 (±1.1318)	0.3336 (±0.0166)	3.9208	0.9800
	2	34.8736 (±7.7176)	0.2314 (±0.0112)	2.7379	0.9799
	3	28.0647 (±2.6748)	0.2324 (±0.0084)	2.7317	0.9732
	4	21.3117 (±9.1952)	0.2701 (±0.0637)	1.1995	0.9543
R^2_{REG}					
P > F					
		K	***N***	**RMSE_PL**	**R^2_{PL}**
T4	0	51.0270 (±0.6595)	0.3056 (±0.0091)	3.5375	0.9897
	1	43.6541 (±3.3760)	0.3079 (±0.0009)	2.8763	0.9805
	2	76.8387 (±2.4754)	0.3011 (±0.0010)	2.2929	0.9929
	3	78.0505 (±8.1780)	0.2920 (±0.0151)	3.8219	0.9701
	4	72.3444 (±1.6348)	0.3032 (±0.0001)	3.4529	0.9842
R^2_{REG}					
P > F					
		K	***N***	**RMSE_PL**	**R^2_{PL}**
T5		119.2503	0.25	3.2265	0.9562

	0	(±9.6909)	63 (±0.0028)		
		107.5704	0.27	2.6837	0.9812
	1	(±6.3910)	77 (±0.0023)		
		108.8564	0.28	1.0612	0.9847
	2	(±8.4867)	66 (±0.0091)		
		119.7405	0.28	4.1180	0.9542
	3	(±9.5875)	30 (±0.0041)		
		115.7318	0.29	2.3921	0.9849
	4	(±3.6332)	57 (±0.0109)		
R^2_{REG}					
***P* > F**					
		K	***N***	**$RMSE_{PL}$**	**R^2_{PL}**
T6		170.2120	0.25	1.1909	0.9944
	0	(±15.8543)	96 (±0.0061)		
		185.0600	0.27	3.5624	0.9661
	1	(±12.6404)	47 (±0.0184)		
		183.1859	0.28	2.6136	0.9573
	2	(±20.2056)	48 (±0.0120)		
		209.1193	0.28	4.3602	0.9242
	3	(±21.5794)	85 (±0.0140)		
		213.7131	0.27	4.4476	0.9586
	4	(±18.9462)	71 (±0.0130)		
R^2_{REG}					
***P* > F**					

Mean values ± standard deviation; n = 3. K = consistency index ($Pa{\cdot}s^n$); n = flow behavior index; RMSE = root mean square error; R^2 = coefficient of determination. C1= 1% thickener, C2 = 2% thickener , T1 = 1% thickener + 3% oat bran, T2= 1% thickener + 6% oat bran, T3= 1% thickener + 9% oat bran, T4 = 2% thickener + 3% oat bran, T5 = 2% thickener + 6% oat bran, T6 = 2% thickener + 9% oat bran.T0 = 0 days, T1 = 8 days, T2 = 15 days, T3 = 22 days, and T4 = 28 days.

The K values (consistency index) varied from 4.9486 to 213.7131 $Pa{\cdot}s^n$ over 28 days, showing an increase in the value of the consistency index according to the increase in the amount of oat bran in each petit suisse. This finding showed that the increase in oat bran in the samples also increased the flow resistence. That was surprisingly that the k value decrease for C2 over the time. Instead, all samples with oat bran added had an increase of K values over the time. The amount of thickener also had an influence on the increase in K value, a differenc that can be seen between controls C1 and C2. The values of flow behavior index(n) (table 7) and apparent viscosity (figure 1) shows that all the samples presented pseudoplastic behavior.

Figure1. Rheological behavior of the petitsuisse described by the Law of Power: relation between the apparent viscosity (Pa • s) and the rate of deformation (s-1).



C1= 1% thickener, C2 = 2% thickener , T1 = 1% thickener + 3% oat bran, T2= 1% thickener + 6% oat bran, T3= 1% thickener + 9% oat bran, T4 = 2% thickener + 3% oat bran, T5 = 2% thickener + 6% oat bran, T6 = 2% thickener + 9% oat bran.T0 = 0 days, T1 = 8 days, T2 = 15 days, T3 = 22 days, and T4 = 28 days.

The results showed that when the amount of oats in petit suise increases, the apparent viscosity and shear stress increase ($p \leq 0.05$) as a function of shear rate.According to the obtained apparenty viscosity, it can be observed that samples with oat bran expressed higher values of viscosity, as the amount of oat bran increased in the samples. Besides, the control C2 expressed higher values only when compared to C1 andT1.The non-relation between a viscosidade aparente (Pa·s) and the shear rate (figura 6) demonstrated a typical behaviour of non-Newtonian fluid, in which the apparent viscosity decrease with the increase in shear rate. It can be seen that there was a increase in apparent viscosity as a function of the the increase of oat in the petit suisse The samples with higher apparent viscosity than C2 was T3, T4, T5 and T6. The treatment T3 presented higher apparent viscosity than C2, even though T3 had half of thickener of C2. Autio et al., (1987) found that the use of small amounts of beta glucan (<0.2%) present in oat bran is able to form viscous solutions that make the fluid to gain pseudoplastic behavior. Petersson et al. (2014) and Lazaridou et al. (2014) agreed that beta glucan has desirable rheological characteristics in the food industry, such as increased viscosity and gelling properties. However, changes in the rheological properties of the product will depend on the molecular weight of beta glucan. Antilla et al., (2004) stated that beta glucan with low molecular weight forms very low viscosity solutions, instead, with high molecular weight, beta glucan forms few viscous solutions even when applied in large quantities.The use of oat bran, mainly due to beta glucan, has been of great interest in the food industry in order to use natural ingredients as additives. Nedeljković et al., (2017) explained that the increase in viscosity of the samples with oat bran is also explained to the high amount of starch content in oat bran, up to 52.39% in dry matter basis. Thus, the starch gelatinization was higher in the samples with higher amount of oat bran. The application of oat bran demonstrated to be effective in gel formation, considering increase in petit suisse viscosity. The ability of oats to form a gel and increase the viscosity when in contact with water is very important to retain whey, while maintaining desirable characteristics for the product and ensuring longer shelf life.

Table8. Water activity of petit suisse

Samples	Water activity
C1	0.985 ± 0.01[a]
T1	0.987 ±0.01[a]
T2	0.986±0.01[a]
T3	0.982±0.01[b]
C2	0.981±0.01[b]
T4	0.980±0.01[b]
T5	0.983±0.01[b]
T6	0.983±0.01[b]

C1= 1% thickener, C2 = 2% thickener , T1 = 1% thickener + 3% oat bran, T2= 1% thickener + 6% oat bran, T3= 1% thickener + 9% oat bran, T4 = 2% thickener + 3% oat bran, T5 = 2% thickener + 6% oat bran, T6 = 2% thickener + 9% oat bran.

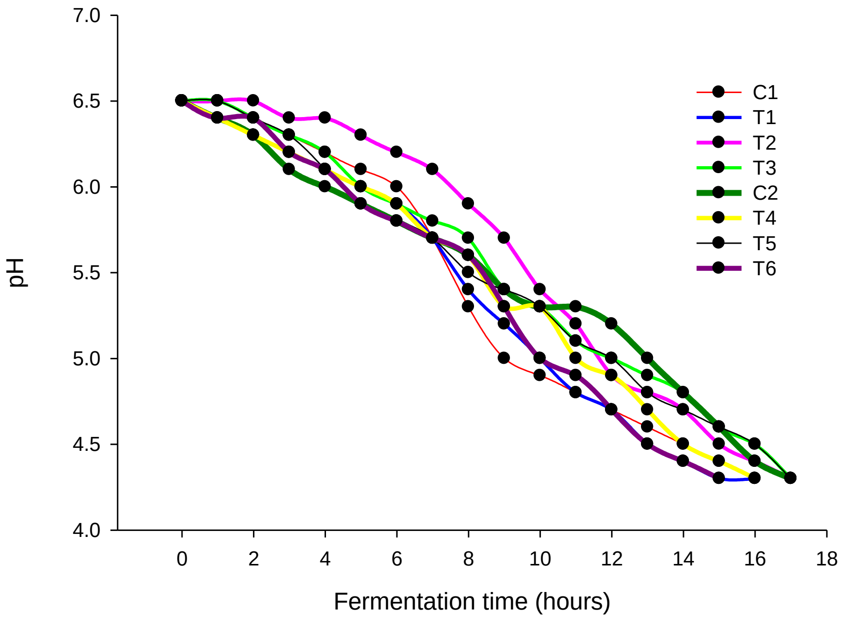
Water activity

The table 8 shows that the water activity of the samples also showed significantly diference ($p \leq 0.05$) for samples T3, T5 and T6 compared to the control (C2). The difference was also due to the oat amount of 6% and 9%, since the samples that presented water activity higher had low or any amount of oat in the petit Suisse formulation.

The decrease of Aw is one very interesting option used by food industries to try to preserve food for longer, since many microorganisms need high values of Aw to develop. Although oat is also helpful to decrease the water activity of petit Suisse, the results still shows that all the samples presented the range of Aw very favorable for the growth of bacteria. Thus, the retained water by samples that had oat occurs due to the bonds of water with macromolecules such as starch, and fibers, which is called adsorbed water.

Fermentation time

Figure2. Fermentation time of petit Suisse with oat added and the control C1 and C2 by Lactococcus lactis subp. Lactis and Lactococcus lactis subp. Cremoris



C1= 1% thickener, C2 = 2% thickener , T1 = 1% thickener + 3% oat bran, T2= 1% thickener + 6% oat bran, T3= 1% thickener + 9% oat bran, T4 = 2% thickener + 3% oat bran, T5 = 2% thickener + 6% oat bran, T6 = 2% thickener + 9% oat bran.

The fermentation time was measured to evaluated the influence of oat in the fermentation. The figure 2 shows the behavior of each sample in the fermentation process. All the samples was inoculated the following acid lactic bacterias Lactococcus lactis subp. Lactis and Lactococcus lactis subp. Cremoris, aiming to produce acid lactic until reach the pH 4,3 at the temperature of 32°C. Although the fermentation time ranged from 15-17 hours, the addition of oat did not have negative influence in the fermentation time. All the samples were not significantly different ($p>0.05$) compared to the controls.

The fermentation time of the petit suisse was measured. The addition of oat did not have negative influence in the fermentation time, that ranged from 15-17h. Some studies investigated the use of acid lactic bacteria to ferment oat. Mårtensson et al. (2002) showed that acid lactic bacterias, such as L. delbrueckii subsp. bulgarius and S. salivarius subsp. Thermophilus exhibit great viability to be applied in oat-based fermented product. Zhang et al. (2015) investigated the oat fermentation and found that this cereal has good potential for application for food rich in lactic acid bactéria. Oat is a fermentable substrate for fermentable substrates for growth of probiotic microorganisms, especially lactobacillus and bifidobacteria (Charalampopoulos et al. 2002). Although we had used the cultures Lactococcus lactis subp. Lactis and Lactococcus lactis subp. Cremoris, those microorganisms might have the same behavior of yogurt cultures: fermentation of the lactose from milk and maltose from oat, the consumption of carbohydrates of the milk and the oat, formation of flavors which turns the use of this cereal very appropriated to use in milk products (Mårtensson et al. 2001). However, the lack of diference in the fermentation time might be due to the preference of lactose as a substrate by Lactis and Cremoris, since the level of lactose was higher than maltose or other substrates. Besides, the incorporation of lactic acid bacteria into beverages that has cereal are appropriated since cereal have a good composition to be fermentable which implicates positively in the growth of lactic acid bacteria (Waters et al. 2013).

Conclusion

It can be concluded that oat bran when added to petit Suisse cheese increase the nutritional value of it. The great water holding capacity presented by the samples with6% and 9% of oat bran allowed to use only half of the amount of thickeners used in the control C2, which suggest the possible reduction of thickener in milk product that has oat bran in the formulation. Also, treatments T3 and T2showed less syneresis than the C2, which increases the shelf life of the product. The TPA characteristics and reological properties showed an increase of hardness, chewiness, adhesiveness, cohesiveness and viscosity, as the amount of oat increased. As it did not has influenced on the fermentation time, oat is a good cereal to be used in petit Suisse in improve nutritional value, technological properties, and a innovation for dairy market.

Acknowledgements

To Federal University of Lavras graduated program. This work was financially supported by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES), Brazil.

Bibliography

AACC. International Submits Comments to FDA on Health Claims Related to Oat Products, 1996.

AOAC. Association of Official Analytical Chemists, 16th ed. Arlington, 1995.

AOAC. Association of Official Analytical Chemists. Official methods of analysis of the association analytical chemists. 18th ed. Maryland, 2005.

AOAC.Official methods of analysis Proximate Analysis and Calculations Ash Determination (Ash) Milk - item 53. Association of Analytical Communities, Gaithersburg, MD, 17th edition, 2006. Reference data: Method 945.46; NFNAP; MIN; ASH

AOAC International,Official Methods of Analysis (1995) 16th Ed., Gaithersburg, MD, sec. 33.2.11, Method 991.20 Nitrogen (Total) in Milk.

AHMAD, A. ET AL. Beta Glucan : A Valuable Functional Ingredient in Foods. **Critical Reviews in Food Science and Nutrition**v. 52, p. 201–212, 2012

ALAKHRASH, F., ANYANWU, U,; Tahergorabi, R. Physicochemical Properties of Alaska Pollock (Theragra Chalcograma) Surimi Gels with Oat Bran.**LWT - Food Science and Technology,** v.66. p. 41–47, 2016.

ALEIXANDRE, A.; MIGUEL, M. Dietary fiber and blood pressure control. Food & Function,v. 7, n 4, p.1864-1871, 2016

ALHASAWI, F.M.et al. In vitro measurements of luminal viscosity and glucose/maltose bioaccessibility for oat bran, instant oats, and steel cut oats. Food Hydrocolloids., v. 70,p. 293-303, 2017.

ANTTILA, H. SONTAG-STROHM, T.; SALOVAARA. H. Viscosity of Beta-Glucan in Oat Products. **Agricultural and Food Science,** v.13, p. 80–87, 2004.

AUTIO, K.; MYLLYMÄKI, O.;MÄLKKI, Y. Flow properties of solutions of oat β -glucans. **Journal of Food Science**, v. 52, p. 1354–1366, 1987.

BARBOSA, B.T.; RODRIGUES, J.F.; BASTOS.S.J.F. 2017. Sensory Optimization of Nutritionally Enriched Strawberry Yogurt. **British Food Journal**, v. 119, n. 2, p. 301–310, 2017.

BARROS, L.S.S.; DELFINO, N.C. 2014. Petit-Suisse Cheese Production with Addition of Probiotic Lactobacillus Casei.**Food and Nutrition Sciences,** *v.* 5, p. 1756–64, 2014.

BEI, Q. et al. Improving Free , Conjugated , and Bound Phenolic Fractions in Fermented Oats (Avena Sativa L.) with Monascus Anka and Their Antioxidant Activity.**Journal of Functional Foods,** v. 32, p. 185–194, 2017.

BIGLIARDI, B.; GALATI, F. Innovation Trends in the Food Industry : The Case of Functional Foods.**Trends in Food Science & Technology,** v. 31, n. 2, p. 118–129, 2013.

BIMBO, F. et al. Consumers ’ Acceptance and Preferences for Nutrition-Modi Fi Ed and Functional Dairy Products : A Systematic Review.**Appetite,** v. 1, n. 113, p. 141-154, 2017.

BORCHANI, C. et al. Physical, functional and structural characterization of the cell wall fractions from baker's yeast *Saccharomyces cerevisiae*. **Food Chemistry,**v.194, p. 1149-1155, 2016.

BRANDELLI, A.; DAROIT, D.J.; and Corrêa, A.P.F. 2015. Whey as a Source of Peptides with Remarkable Biological Activities.**Food Research International,** v. 73. p. 149–61, 2015.

BRASIL. Regulamento Técnico de Identidade E Qualidade de Queijo Petit Suisse. 2000

BRENNAN, C.S.; LOUISE, J.C. The Potential Use of Cereal (1/3,1/4)-B-D-Glucans as Functional Food Ingredients.**Journal of Cereal Science**, v. 42, p. 1–13, 2005.

BULL, S.P. et al. Whey Protein Mouth Drying Influenced by Thermal Denaturation.**Food Quality and Preference**, v. 56, p. 233–240, 2017.

CARDARELLI, H. R.Inulin and Oligofructose Improve Sensory Quality and Increase the Probiotic Viable Count in Potentially Synbiotic Petit-Suisse Cheese.**LWT - Food Science and Technology**, v. 41, p. 1037–1046, 2008

CHARALAMPOPOULOS, D. et al. Application of cereals and cereal components in functional foods: a review. **International Journal of Food Microbiology,** v. 79, p. 131–14, 2002.

CHAWLA, R. AND PATIL, G.R. 2010. Soluble Dietary Fiber. Comprehensive Reviews in Food Science and Food Safety, 9, 178-196.

CHEN, H. et al. Chemical, Physical and Baking Properties of Apple Fiber Compared with Wheat and Oat Bran. **Cereal Chem**, v. 65, n. 3, 244-247, 1988.

COLLINS, F. WILLIAM. Oat Phenolics: Avenanthramides, Novel Substituted N-Cinnamoylanthranilate Alkaloids from Oat Groats and Hulls.**Journal of Agricultural and Food Chemistry**, v. 37. n. 1,p. 60–66, 1989

DAOU, C.; ZHANG, H. Oat Beta-Glucan : Its Role in Health Promotion and Prevention of Diseases. **Comprehensive Reviews in Food Science and Food Safety**, v. 11, p. 355–65, 2012.

DHINGRA, D. et al. (2012). Dietary fibre in foods: a review. **J Food Sci Technol**, v. 49, n. 3, p. 255–266.

EKSTRÖM, L.M.N.K. et al. Oat Β -Glucan Containing Bread Increases the Glycaemic Profile. **Journal of Functional Foods**, v. 32, p. 106–111, 2017.

ELORANTE, A-M.et al. 2016. Food Sources of Energy and Nutrients in Finnish Girls and Boys 6-8 Years of Age - the PANIC Study.**Food & Nutrition Research**, v. 1, p. 1–12.

ESMERINO, E. A. et al. 2015. Survival Analysis : A Consumer-Friendly Method to Estimate the Optimum Sucrose Level in Probiotic Petit Suisse. **Journal of Dairy Science,**v. 98, n. 11, 7544-7551, 2015.

ESMERINO, E.A. et al. 2013. The Influence of Sweeteners in Probiotic Petit Suisse Cheese in Concentrations Equivalent to that of Sucrose.**Journal of Dairy Science,** v.96, n. 9, 5512–5521.

FDA. FDA allows whole oats foods to make health claim on reducing the risk of heart disease. Food and Drug Administration. U.S. Department of Health and Human Services. 1997

FDA. FDA: CFR - Code of Federal Regulations Title 21. FOOD FOR HUMAN CONSUMPTION. Vol.2. 2016.https://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfcfr/cfrsearch.cfm?fr=870.5225.

FDA. FOOD AND DRUG ADMINISTRATION. CFR - Code of Federal Regulations Title 21. SUBCHAPTER B--**FOOD FOR HUMAN CONSUMPTION.** 2016.

CODEX ALIMENTARIUS COMMISION (CAC), Reported of the 27th session of the Codex Committee on Nutrion And Foods for Special Dietary Uses, Bonn, Germany, 21-25 November 2005.

FERREIRA, Daniel Furtado. Sisvar: a Guide for its Bootstrap procedures in multiple comparisons.*Ciênc. agrotec.* [online]. 2014, vol.38, n.2 [citado 2015-10-17], pp. 109-112 . Disponible en: ISSN 1413-7054. http://dx.doi.org/10.1590/S1413-70542014000200001

FERREIRA-PINTO, L. et al.Supercritical Water Oxidation of Lactose.**The Canadian Journal of Chemical Engineering**, v. 95, p. 827–831, 2017.

FULGONI, V.L.ScienceDirect Oatmeal Consumption Is Associated with Better Diet Quality and Lower Body Mass Index in Adults : The National Health and Nutrition Examination Survey. **Nutrition Research**,v. 35, n. 12, 1052–1059, 2015.

GAJENDRAGADKAR, C.N.; GOGATE, P.R. Ultrasonics Sonochemistry Intensified Recovery of Valuable Products from Whey by Use of Ultrasound in Processing Steps – A Review.**Ultrasonics Sonochemistry,** v.32, p. 102–118,2016.

GELROTH, J.; RANHOTRA, G. S. Food uses of fibre. In: Hand Book of Dietary Fibres, pp. 435–451 Sussan-Sungsoo, C. and Dreher, M. L., Eds., Marcel Dekker-Inc., New York, 2001.

GÜLER-AKIN, M.B; FERLIARSLAN, I.; AKIN, M.S. 2016. Apricot Probiotic Drinking Yoghurt Supplied with Inulin and Oat Fiber.**Advances in Microbiology**, v. 6, 999–1009, 2016.

HASHIM, B.I.; KHALIL, H.; AFIFI, H.S. Quality characteristics and consumer acceptance of yogurt fortified with date fiber. **J. Dairy Sci.**, v. 92, p. 5403–5407, 2009.

HITAYEZU, R. et al. 2015. Antioxidant Activity, Avenanthramide and Phenolic Acid Contents of Oat Milling Fractions. **Journal of Cereal Science**, v. 63, p.35-40, 2015.

HEINI, R.L. et al.Sensory characteristics of wholegrain and bran-rich cereal foods – A review. **Trends in Food Science &Technology**, v. 47, p. 25-38, 2016.

HENEEN,W.K. et al. The distribution of oil in the oat grain. **Plant Signal Behav,** v. 4, n. 1, p. 55–56, 2009.

HITAYEZU, R. et al. Antioxidant activity, avenanthramide and phenolic acid contents of oat milling fractions. Journal of Cereal Science, v. 63, p. 35-40, 2015.

HUGHES, E.; COFRADES, S.;TROY, D.J. Effects of Fat Level , Oat Fibre and Carrageenan on Frankfurters Formulated with 5, 12 and 30 % Fat.**Meat Science,** v. 45, n. 3, p. 273–281, 1997.

INGLETT, G.E. et al. 2014. Pasting and Rheological Properties of Oat Products Dry-Blended with Ground Chia Seeds.**LWT - Food Science and Technology**, v. 55, n. 1, 148–156, 2014.

KUREK, M. et al. The Effect of Oat Fibre Powder Particle Size on the Physical Properties of Wheat Bread Rolls. **Food Technology and Biotechnology**, v. 54, n. 1, p. 45-51, 2015.

LADJEVARDI, Zh.S. et al.Physicochemical Properties and Viability of Probiotic Bacteria of Functional Synbiotic Camel Yogurt Affected by Oat β - Glucan during Storage.**J. Agr. Sci. Tech**, v. 18, p. 1233–1246, 2016.

LAZARIDOU, A, B., C.G.;Izydorczyk, M.S.Molecular Size Effects on Rheological Properties of Oat B -Glucans in Solution and Gels.**Food Hydrocolloids**, v. 17, p. 693–712, 2003.

LAZARIDOU, A. et al. Structure Development and acidification Kinetics in fermented milk containg oat b-glucan, a yogurt culture and probiotic strain. **Food Hydrocolloids,** v. 34, p. 204-214, 2014.

LIU, R. et al. Effects of ultrafine grinding and cellulase hydrolysis treatment on physicochemical and rheological properties of oat (*Avena nuda* L.) β-glucans.**Journal of Cereal Science,** v. 65, p. 125-131, 2015

MARSHALL, K.Therapeutic Applications of Whey Protein.**Alternative Medicine Review**, v. 9, n. 2, p. 136–156, 2004.

MARTÍNEZ-VILLALUENGA, C.; PEÑAS. E.ScienceDirect Health Benefits of Oat : Current Evidence and Molecular Mechanisms ´ Nez-Villaluenga and Elena Pen.**Current Opinion in Food Science,** v. 14: p. 26–31,2017.

MAJZOOBI, M. et al. Comparison of Physicochemical and Gel Characteristics of Hydroxypropylated Oat and Wheat Starche. **International Journal of Food Engineering**, v. 10, n. 4, p. 657-667, 2014.

MACFIE, H.J. et al.Designs to balance the effect of order of presentation and first-order carry-over effects in hall tests. **J.SensoryStudies,** v. 4, n. 129–148, 1989

MÅRTENSSON, O. et al. Formulation of an oat-based fermented product and its comparison with yoghurt.**Science of Food and Agriculture,** v. 81, p. 1314-1321, 2001.

MÅRTENSSON, O.; ÖSTEB, R.; HOLST, O. The effect of yoghurt culture on the survival of probiotic bacteria in oat-based, non-dairy products. **Food Research International,** 35, 775–784, 2002.

MUDGIL, D.; BARAK, S. 2013. Composition, Properties and Health Benefits of Indigestible Carbohydrate Polymers as Dietary Fiber : A Review.**International Journal of Biological Macromolecules**,v. 61, p. 1–6, 2013.

NEDELJKOVIĆ, N. et al. Partial Replacement of Fat with Oat and Wheat Bran Gels : Optimization Study Based on Rheological and Textural Properties.**LWT - Food Science and Technology,** v. 86, p. 377–84, 2017.

NINGTYAS, D.W. et al. Texture and lubrication properties of functional cream cheese: Effect of β-glucan and phytosterol. JOUrnal of texture studies, v. 49, n. 1, p. 11–22, 2018.

OZCAN; T.; KURTULDU, O. Influence of Dietary Fiber Addition on the Properties of Probiotic Yogurt. International Journal of Chemical Engineering and Applications, vol. 5, n. 5, p. 397-401, 2014

PAPPALARDO, G.; LUSK, J.L. The Role of Beliefs in Purchasing Process of Functional Foods.**Food Quality and Preference**,v. 53., p. 151–58, 2016.

PAULA, R. de, et al.Effect of Processing on the Beta-Glucan Physicochemical Properties in Barley and Semolina Pasta. ***Journal of Cereal Science,*** v. 75. p. 124–131, 2017.

PEREIRA, E.P.R.Effect of Incorporation of Antioxidants on the Chemical , Rheological , and Sensory Properties of Probiotic Petit Suisse. **Journal of Dairy Science,** v. 99 p. 1–11, 2016.

PETERSSON, K. et al.The Effects of Cereal Additives in Low-Fat Sausages and Meatballs. Part 2: Rye Bran, Oat Bran and Barley Fibre.**Meat Science**, v. 96, n. 1., p. 503-508, 2014.

PRUDENCIO, I.D. et al. Petit Suisse Manufactured with Cheese Whey Retentate and Application of Betalains and Anthocyanins. **LWT - Food Science and Technology,**v. 41, p. 905–10, 2008.

RAMÍREZ-SANTIAGO, C. et al. Viscoelastic Properties and Overall Sensory Acceptability of Reduced-Fat Petit-Suisse Cheese Made by Replacing Milk Fat with Complex Coacervate.**Dairy Science & Technology,**v. 92, p. 383–398, 2012.

RASANE, P. ET AL. Nutritional Advantages of Oats and Opportunities for Its Processing as Value Added Foods - a Review.**J. Food Sci. Technol,**. v. 52,p. 662–675, 2013.

REDDY, D. M. Effect of oat flour on physcico-chemical characteristics of mutton nuggets. **International Journal of Science, Environment and Technology,** v. 6, n. 1, p. 248–253, 2017.

RIEDER, A.; KNUTSEN; S.H.; BALLANCE.S. In Vitro Digestion of Beta-Glucan Rich

Cereal Products Results in Extracts with Physicochemical and Rheological Behavior like Pure Beta-Glucan Solutions - A Basis for Increased Understanding of in Vivo Effectts.**Food Hydrocolloids**, v. 67, p. 74–84, 2017.

RIENER, J. et al. A Comparison of Selected Quality Characteristics of Yoghurts Prepared from Thermosonicated and Conventionally Heated Milks.**Food Chemistry,**v. 119, n. 3, p. 1108–1113, 2010.

RUSSO, P. et al. Lactobacillus Plantarum Strains for Multifunctional Oat-Based Foods.**LWT - Food Science and Technology**, v. 68, p. 288–94, 2016.

SANTOS, R.O. et al.Prebiotic flours in dairy food processing: Technological and sensory implications. **International Journal of Dairy Technology,** v. 70, p. 1-10, 2017.

SARTESHNIZI, R.A. et al. Optimization of prebiotic sausage formulation: Effect of using β-glucan and resistant starch by D-optimal mixture design approach. LWT - Food Science and Technology, v. 62, n. 1, p. 704-710, 2015

SARTESHNIZI, R.A. et al. Effect of Resistant Starch and β-Glucan Combination on Oxidative Stability, Frying Performance, Microbial Count and Shelf Life of Prebiotic Sausage During Refrigerated Storage. Food Technol. Biotechnol., v. 55, n. 4, p. 475-483, 2017

STEINERT, R.E.S.; Raederstorff, D.; Wolever, T.M.S. Effect of Consuming Oat Bran Mixed in Water before a Meal on Glycemic Responses in Healthy Humans—A Pilot Study. Nutrients, v.8, n. 9, p. 524, 2016.

STEPHEN, A.M. et al. Dietary fibre in Europe: current state of knowledge on definitions, sources, recommendations, intakes and relationships to health. Nutrition Research Reviews, v. 30, n. 2, p. 149-190, 2017.

SINGH, N. B.; SINGH, R.; IMAM, M.M. Waste water management in dairy industry : pollution. **International Journal of Science, Environment and Technology,** v. 3, n. 2, p. 672–83, 2014.

SMITHERS, G.W. 2008. Whey and Whey Proteins — From ‘ Gutter-to-Gold .’**International Dairy Journal**, v. 18, p. 695–704, 2008.

SOUZA, V.R. de. et al. Analysis of various sweeteners in petit suisse cheese : determination of the ideal and equivalent sweetness.***Journal of Sensory Studies*,** n. 2002, p. 339–45, 2011.

SUNILKUMAR, B.A.et al. Identification and Characterization of High Protein Oat Lines from a Mutagenised Oat Population.***Journal of Cereal Science*.** 2017.

TALUKDER, S.; SHARMA, D.P. Development of dietary fiber rich chicken meat patties using wheat and oat bran. **Journal of Food Science and Technology**, v. 47, n. 2, p. 224–229, 2010.

WANG, S. et al. Starch retrogradation: A comprehensive review. **Comprehensive Review in Food Scince and Food Safety**, v. 14, p. 568-585, 2015.

WANG, P. et al. Oat Avenanthramide-C (2c) Is Biotransformed by Mice and the Human Microbiota into Bioactive Metabolites.**The Journal of Nutrition**, v. 9, p. 239–245, 2015

WANG, S.J.; COPELAND L. Molecular disassembly of starch granules during gelatinization and its effect on starch digestibility: a review. ***Food Function,*** v. 4, p. 1564–80, 2013.

WALTERS, M. et al. Phenolic acids, avenanthramides, and antioxidant activity of oats defatted with hexane or supercritical fluid. **Journal of Cereal Science**, v. 79, p. 21-26, 2018.

WATERS, D.M. et al. Lactic Acid Bacteria as a Cell Factory for the Delivery of Functional Biomolecules and Ingredients in Cereal-Based Beverages: A Review. **Critical Reviews in Food Science and Nutrition**, v. 55, p. 503–552, 2015.

WHITEHEAD, A.;Beck, E.J.; Tosh. S.; Wolever. T.M.S. Cholesterol-lowering effects of oat β-glucan: a meta-analysis of randomized controlled trials. The American Journal of Clinical Nutrition, v. 100, n. 6, p. 1413–1421, 2014.

WOLEVER. T.M.S. Effect of adding oat bran to instant oatmeal on glycaemic response in humans – a study to establish the minimum effective dose of oat β-glucan. Food Funct., 2018

WOOD, P.J. Cereal β-glucans in diet and health. **Journal of Cereal Science**, v. 46, p. 230-238, 2007.

ZHANG, M.; BAI, X.; ZHANG, Z. Extrusion process improves the functionality of soluble dietary fiber in oat bran.**Journal of Cereal Science**, v. 54, n. 1, p. 98-103, 2011.

ZHANG, N. et al. Solid-state fermentation of whole oats to yield a synbiotic food rich in lactic acid bacteria and prebiotics. **Food Funct,** v. 6, n. 8, p. 2620-2625, 2015.

ZHOUA, M. Oat Lipids. **Journal of the American Oil Chemists' Society,** v. 76, n. 2, p. 159-169, 1999.

ZHU, F. Structures, properties, modifications, and uses of oat starch.**Food Chemistry**, v. 229, p. 329-340, 2017.

ARTIGO 2: Acceptance of petit Suisse with oat bran and different sweeteners

Será submetido á Food Research International, sendo apresentado de acordo com as regras de publiucação dessa revista.

Ana Paula Lima Ribeiro[a], Michel Cardoso de Angelis Pereira[a], Luiz Ronaldo de Abreu[a], Sandra Maria Pinto[a]

a Department of Food Science, Federal University of Lavras, 37200-000, Lavras, MG,

*Corresponding author: Ana Paula Lima Ribeiro, Department of Food Science, Federal University of Lavras, UFLA, CEP 37200-000 Lavras, MG, Brazil. Tel.:+55 35 992141540. E-mail address: anaplima.com@gmail.com

ABSTRACT

Oats is a cereal rich in protein, minerals, in addition to antioxidants. It is very consumed by high fiber content. When consumed regularly, it is able to diminish from many diseases. In addition, oats have many industrial applications because of their high water holding capacity and gel formation. Besides, a diet based in high consumption of fibers and low ingestion of sugar is a good combination for a balanced diet. The aim of the study was 1) to evaluated the acceptance of petit suisse cheese with oat bran and 2) investigated different sweeteners to increase the range of product with sucrose free and diabetic diets. To meausre the ideal concentration of oat bran in the acceptance test, petit suisse samples were manufactured with 4 different amounts of oat bran (3%, 6% , 9% and 12%). The ideal sucrose of petit suisse was also evaluated. Equivalent sweeteners test, check all that apply and global acceptancewas performed using the follow sweeteners: xilitol, erytritol, sucralose and stevia. The results indicated good acceptance of the panelists for petit suises with oat bran added. The best formulationof petit suisse was with 6% oats and 16% sugar. The sugar substitutes that had the best overall acceptance were erythritol and xylitol. The results showed that the use of oats in petit suisse is an alternative that brings nutritional benefits to the consumer and technological to the company. Substitution of sugar by sweeteners was well accepted by consumers in petit suisse with addition of oats.

Keywords: Functional Foods. Cereal. Sweeteners.

Introduction

The modern consumer is claiming for food with health benefits. Consumers are highly driven by health-enhancing food products (Pappalardo and Lusk 2016; Bimbo et al. 2017). Thus, many manufactured products have been innovating food product formulation to call consumers attention and to stand out from competitors (Bigliardi and Galati 2013). Milk and milk products are naturally good source of proteins, carbohydrate, vitamins and minerals (Elorante et al. 2016) and the consumption must be encouraged for all ages. While dairy product is a good source of nutrients, it is not a good source of dietary fibers. Hence, some studies make effort to incorporate cereals in milk products (Güler-Akın, Ferliarslan, and Akın 2016; Barbosa, Rodrigues, and Bastos 2017) .

Oat is consumed in the whole world and it is considered a cereal that promotes health. This grain is processed by different forms to produce oat based food products with health beneficial properties (Rasane et al. 2013). Many studies has proven the benefits of oat consumption (Ekström et al. 2017; Wang et al. 2015) . Oat is one of the cereal richest and economical source of high quality proteins, ranging 12% to 15% (Sunilkumar et al. 2017) and soluble dietary fiber, including β-glucan, (Russo et al. 2016), in which the consume results in lower cholesterol and blood glucose in human body (Daou and Zhang 2012). Although much of the research oats has focused on its β-glucan, recently researches indicates that this cereal may contain other beneficial components. Oat is also studied because of the amount of tocols (tocopherol and tocotrienol), phenolic compounds such as phenolic acids, flavonoids (Hitayezu et al. 2015; Bei et al. 2017, Walters et al. 2018) and Avenanthramides, an unique antioxidant found only in oat yet (Collins 1989). Oat contains several components that emerges health-promoting properties (Fulgoni et al. 2015). The modern industry has made efforts to use of oat in many food products, including biscuit, bread, yogurt, cereal bars to increase the range of functional in the market (Martínez-Villaluenga and Peñas 2017).

The concern of food producers is increase the nutritional content table of food products and decrease non-health ingredients to attend consumer’s expectation. Although sweet tasting food is very enjoyable by consumers, the concern of sugar ingestion had a great increase since it is major contributor of calories to diet, caries and health problems. Consumption of sugar sweetened beverages is a major cause of obesity and diabetes (Gupta et al. 2014). The popularity of sugar free food increase the interest in sweeteners. Artificial sweeteners have controversial health and metabolic effects (Chattopadhyay et al. 2014), which make important the increase in sweeteners from natural sources. Natural ingredients have been gaining a great interest of food industry and consumers since they are viewed as better than the chemical additives (Carocho et al., 2015). Recent researches has made possible to offer a large number of compounds present in plant that offers sweet taste and low calories (Priya et al., 2011). Sugar alcoohols come from natural sources and are also recommend as a sugar replacer (Grembecka et al. 2014), i.e. xylitol, erythritol, sorbitol, mannitol, isolmalt and lactitol (EC, 2014). Sugar alcohol are poliols that act like sugar replacers since it is known as nutritive sweeteners that come from natural sources (Grembecka et al. 2014). This sweeteners are extracted from fruits and vegetables, and are used as ingredient for chocolates, desserts and pastries (Overduin, et al. 2016). Those sweeteners have the same sweetness, or even a lower sweetening power than sucrose. Althgouh polyol products are more expensive than sucrose, their use can be supplement with intense sweeteners, and they can be marketed for the added benefits they inherently bring (Zumbé et al., 2001). Natural sweeteners with high intensity sweetener have also been shown to have importance in food products. Stevia rebaudiana Bertoni is native from northeastern Paraguay, although it has been growing around the world (Šic Žlabur et al. 2013). The main components of Stevia are stevioside (4-10%), rebaudioside A (2-4%), rebaudioside C (1-2%), and dulcoside A (0.5-1%) (SUPRIYADI et al. 2016). The stevioside has a sweetening power of the sucrose of 250–300 and rebaudioside A with a sweetening power 300–450 and they are the main components responsible for the sweetness taste (Jentzer et al., 2015; Gasmalla et al. 2014). Besides, this sweetener contain polyphenols that inhibit hydroxyl radical, nitric oxide, superoxide anion, and hydrogen peroxide scavengers, which increase the health benefits of milk product when it is added (Narayanan et al., 2014).Sucralose is an articifial sweetener derived from sucrose by the selective replacement of three hydroxyl groups by chlorine atoms (Mortensen, 2006). The sweetening power is 600 times higher than sucrose (Furlán et al., 2016), and it is appropriated to a wide range of food products and beverages since is highly stable under a variety of processing conditions. (Mortensen, 2006; VASILESCU et al., 2011).

Food nutrition is moving toward food innovation. Thus, it is very important to pay attention on dairy product consumers' preference, once it may benefit both consumers and dairy manufacturers (Bimbo et al. 2017). Besides, to promote consumption of functional dairy foods to consumers with dietary restrictions it becomes interesting to add some variants it the products, such as sweeteners (Narayanan et al., 2014)

The aim of this study was to evaluated the acceptance of petit Suisse cheese with oat to increase the sensory and nutritional characteristics to turn cheese more popular among adults. It was investigated different sweeteners to increase the range of product with sucrose free and diabetic diets.

Material

The following is a list of materials used in the food preparations in this study: pasteurized skim milk (0.0% w/w), mesophilic yeast Lactococcus lactis ssp. Lactis and Lactococcus lactis ssp. Cremoris (Chr. Hansen), commercial oat bran (Quaker Oat Bran™), Sucralose (Splenda), Xilitol (Essential), Erithritol (Essential),Stevia with 95% of reabaudioside, commercial sucrose (União, Tarumã, SP, Brazil).

Preparation of petit Suisse chesse

The petit suisses cheeses were manufacture with different concentrations of commercial oat bran (2,3g protein, 1,1g fat, 2,9g carbohydrates, dietary fiber 2,5g per 10g of oat bran as specified by the manufactor), skimmed milk (0%), sugar (10%) and pasteurized at 80°C/30 min. The mixture was cooled to 32°C to add mesophilic yeast (L. lactis ssp. *lactis* and L. lactis ssp. *cremoris*) and rennet. The ingredients were mixture and fermented for an average of 14 hours until reach pH 5.6. The curd was broken up and shaken for 5 minutes. Four concentration of oat bran was chosen (3%, 6%, 9% and 12%) to add in petit suisse. No study reported the addition of oat in petit suisse cheese. Thus, it was necessary to perform preliminary experiments. Petit Suisse was storage to 4°C for further analysis.

Sensory Analysis

All the sensory evaluation only was carried out after approval by the Committee of Ethics in Research with Human Beings (COEP) under protocol CAAE 70881917.9.0000.5148, according to resolution number 196/96 of the National Health Council (BRASIL, 1996).

Acceptance test

Acceptance test was conducted using four concentration of oat bran in petit Suisse (3, 6, 9 and 12%) to determine the optimal amount of oat bran according to the consumers preference. The analyses were carried at in the Sensory Analysis Lab, Department of Food Science of Federal University of Lavras. A total of 100 panelists were used, and most of them were male (67%). The samples were presented to the panelists in disposable plastic cups coded with three-digit numbers using in a balanced complete blocks paradigm (Macfie et al. 1989). The panelists evaluated the samples using an evaluation sheet and the scale anchored to +1 (extremely dislike) to +9 (extremely like). Scott Knott test was used to determine differences between the means and the significance was determined at P ≤0.05 to find the best formulation of petit Suisse cheese with oat bran.

Ideal sucrose

The petit Suisse with ideal concentration of oat bran was analysed in the test of ideal sucrose. The ideal sucrose was defined considering there is no preestablished concentration of sugar in petit Suisse in Brazilian legislation. The test of ideal sucrose was based in formulation used by Esmerino et al., (2013) with minor modification. Five formulations of Petit Suisse cheese with the ideal amount of oat bran, according to acceptance test, were prepared varying only in sucrose concentration: 7.5, 11, 14,5, 18, and 21,5% (wt/wt). The definition of the central point of sucrose was based on the concentration of sucrose normally used in products already on the market.

One hundred panelists were recruited among students and employees on the Federal University of Lavras. The panelists were aged between 18 and 50 years old, and the majority (65%) being women. The samples was served in codified transparent plastic disposable cups coded with three digit numbers using balanced complete blocks paradigm (Macfie et al. 1989). Water was also provided, and the panelists were informed to drink water between samples to neutralize flavors. The panelist used the 10 cm non-strutred scale anchored at the extreme left by “extremely less sweeter than the ideal”, the central point in the middle of the scale, being the ideal of sucrose and the right by “extremely sweeter than the ideal”. Analysis of linear regression between the scores and sucrose concentrations was applied to identify the scored concentration of sucrose in petit Suisse with oat bran.

Determination of equivalent sweeteners

The determination of equivalent sweeteners is performed according to Wald (Amerine et al. 1965) and composed by three steps, in which the first is the selection of panelists. In the first step, triangular test was applied to select only discriminative panelists. Two samples of petit Suisse was prepared with significance difference of 1% of sucrose. In the triangular test, three samples were presented, and only one sample presented 0.02% of sucrose. The participants needed to identified which sample were different. The participants were choosen according to the Wald's sequential, using the maximum incapability acceptable was defined (P = 0.30), the minimum acceptable skill (P1 = 0.70), the probability of accepting a candidate without sensory acuity (a=0.10) and the probability of rejecting an applicant with sensory acuity (b=0.10). The panelists were judged according to the graph made by the parameter above, in which result in acceptance, rejection and decision area.

From the triangular test, 15 judges were selected and lead to the second step: the panelists training. In this step, the panelists received information about the test and the use of magnitude scale. The panelists were trained to differentiate samples with different scores of sucrose (10, 16 and 25.6) in which the middle point was determined by equivalent sweeteners test and the higher and lower level of sucrose determined by 1.6 factor.

The last step was the final test. Five sessions of equivalent sweeteners was performed. In each session, the selected and trained panelists received one reference sample, with the ideal sucrose established previously and five samples with different concentration of the sweetener. The middle point of each sweetener was equivalent to the ideal sucrose. The intensity of two samples with higher and lower sweetener compared to the reference was established using 1.6 factor (Table 1)

Table1. Concentration of sweeteners used in magnitude test for determining the equivalent of sweeteners

Sweetener	Equivalent Sweeteness (%)				
Sucrose	6.25	10.00	16.00	25.60	40.96
Sucralose	0.011	0.017	0.027	0.044	0.070
Stevia	0.037	0.058	0.094	0.150	0.240
Xylitol	6.60	10.5	16.8	26.90	43.00
Erithytol	9.60	15.40	24.60	40.00	63.00

For the magnitude test the panelists were asked to evaluated each sample according to the reference sample. The value of the reference sample was 100. If the sample was twice sweetness of the reference, the panelist was instructed to give value 200. If the sample was half of sweetness of the reference, it should receive value of 50.

Check all apply and global acceptance

Check all apply (CATA) experiment was conducted to measure all attributes noticed in the samples according to the panelists. The amount of 100 panelists, the majority was female 74%, was invited to participate in the test. They were served 5 samples of petit Suisse with 4 different sweeteners and one sample with sucrose. The amount of sweetener and sucrose of each petit Suisse was based in determination of equivalent sweeteners and ideal sucrose test.The samples was coded in three digit numbers and served in a monadic form. The panelist was informed that they need to try the samples and mark in list of words all attribute that they consider appropriate to describe a product. The CATA question was comprised by 9 terms related to the sensory characteristics of the petit Suisse with addition of oat: metallic taste, oat flavor, sweetenes, mint taste, chemical-like sensation, acid flavor, milky flavor, bitterness, aftertaste. The terms was selected based on published data (Cadena et al., 2014 and Castura et al., 2016) and answers from trained panelists, that defined the attributes in open discussion. The order of terms used in CATA question was balanced following William's Latin Square experimental design (Willians, 1949). After CATA test, the participant was instructed to evaluate the samples using a evaluation sheet and the scale anchored to +1 (extremely dislike) to +9 (extremely like) to determine only the overall impression of the product. Scott Knott test was performed to determine the preference of the consumers about petit Suisse cheese with addition of oat and sweeteners, and CATA test was analyzed by a frequency analyses.

Results

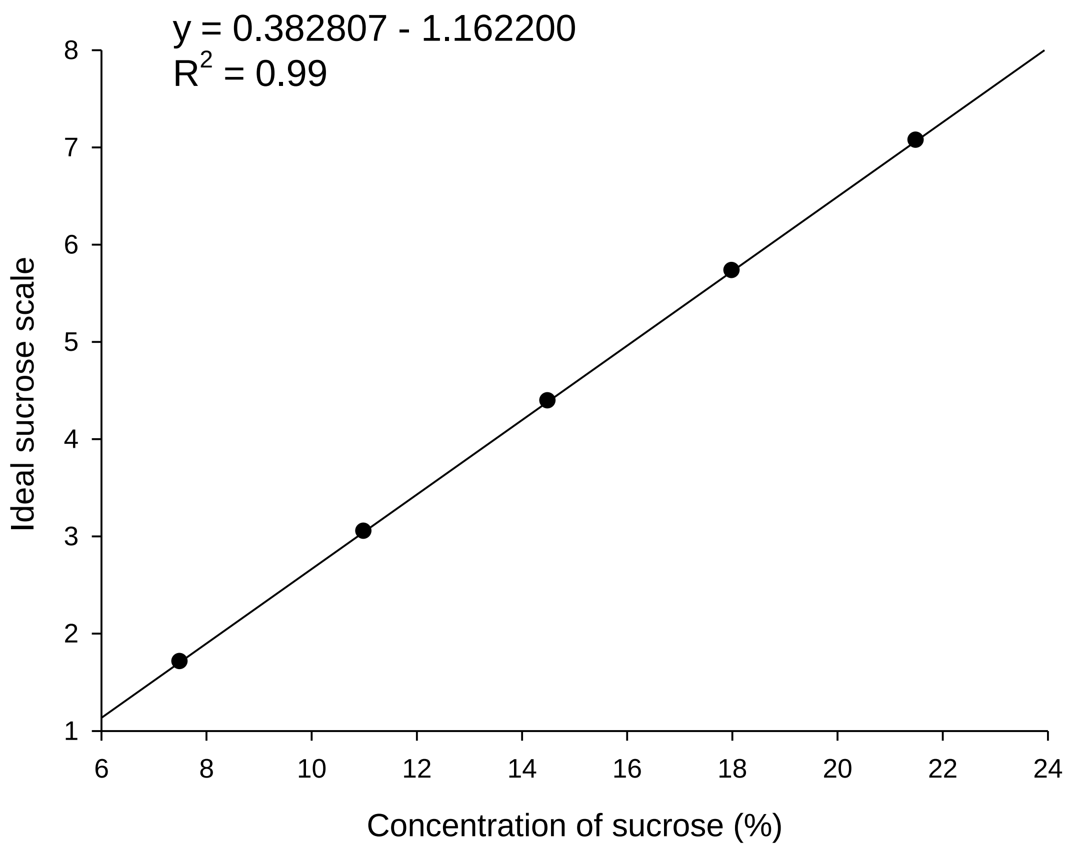
Table2. Average of the hedonic values obtained by the acceptance tests in relation to the attributes color, aroma, flavor, texture and overall impression of petit suisse with different levels of oats

Treatment (Oat bran %)	Appearence	Taste	Aroma	Texture	Overall impression
T1 (3%)	6.65[a]	7.72[a]	6.56[a]	6.92[a]	7.9[b]
T2 (6%)	6.93[a]	8.02[b]	6.73[a]	7.47[b]	8.17[b]
T3 (9%)	6.91[a]	7.73[a]	6.61[a]	6.93[a]	7.6[a]
T4 (12%)	6.70[a]	6.38[a]	6.31[a]	6.52[a]	6.36[a]

Means followed by equal letters in the lines do not differ from each other at the 5% level by the Scott-Knott test. T1 = 3%, T2 = 6%, T3 = 9% and T4 = 12% of oat.

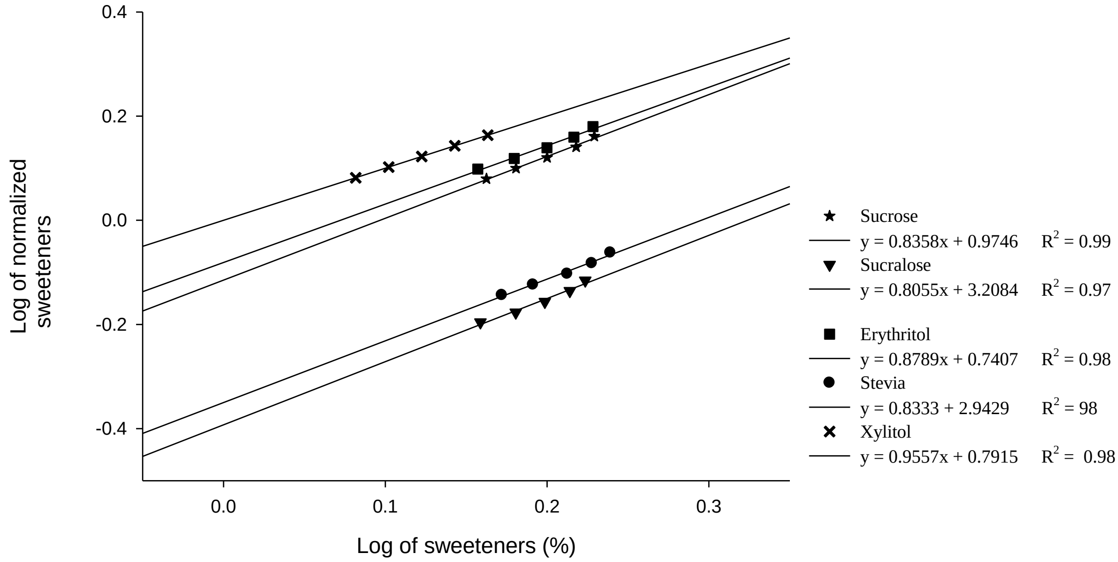
The acceptance of petit Suisse with oat added was evaluated by acceptance test. Table 2 demonstrated different results for the attributes evaluated. This indicates that the amount of oat added in all samples had different acceptance by the panelists. The addition of 6% of oat caused significant (P≤ 0.05) increase in taste and texture. The addition of 3% and 6% increased the overall impression, however, over 6%, there was an decrease of acceptance. For appearance and aroma, the amount of oat did not showed difference between the treatments. The amount of 6% of oat was choosen based on overall impression, texture, taste andother factors, as can be seen in the discussion.

Figure1. Ideal sucrose of petit Suisse cheese according to responders.



The ideal sucrose was stipulated. Although the literature presents the ideal sucrose in strawberry petit suisse, the ideal concentration of sucrose varies with the type of product (Morais et al. 2014) . The test was carried out since the addition of oat could have influence in the sweetness preference of the panelists. A regression model was adjusted to represent the data from ideal sucrose test, according to figure 1. The figure shows that the ideal sweetness to petit suisse with oat and sucrose was 16%, result that is in accordance with previous researches, as can be seen in the discussion.

Figure2. Linearized power function of petit Suisse with oat sweetened with sucrose, sucralose, stevia, erythritol and xylitol.



The position of each curve, in the figure 2, is possible to evaluate the sweeteners power of each sweetener perceived by the panelists according to determination of equivalent sweeteners test. The curves above the sucrose curve shows a sweetener with lower sweetness power compared to sucrose. Instead, the curves below the sucrose curve have a higher intensity power sweeter.

The table 3 shows the parameters angular coefficient (A), the intercept on the ordinate (n), the linear coefficient of determination (R^2) and the power function of the sweeteners evaluated in this study. The determination of concentration (C) of each sweetener was based in the power function of sucrose. The stimuli perceived by the panelists were given by S. The value of sucrose stimuli perceived was S = 95,72**.** A linear regression curve was obtained for sucrose and the various sweeteners (Figure 2).

Table3. The values of angular coefficient (A), intercept on the ordinate (n), linear coefficient of determination (R^2), and power function of the results to determine the equivalent sweetness of each sweetener used in petit Suisse cheese with oat.

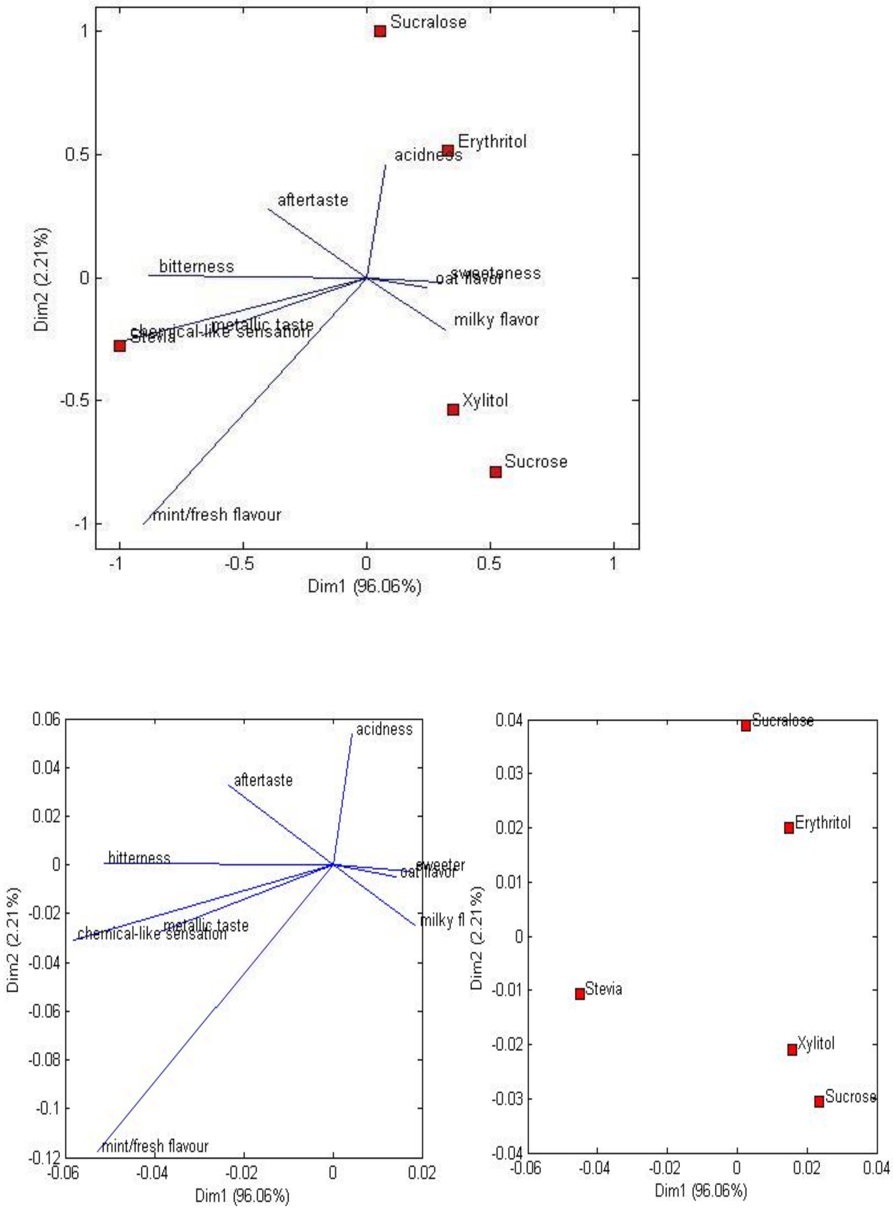
Sweetener	A	N	R	Power function
Sucrose	9.4319	0.9746	0.9922	$S= 9.4319xC^{0.8358}$
Erythritol	0.8789	0.7407	0.986	$S= 5,5042xC^{0.8789}$
Xylitol	0.9557	0.7915	0.9842	$S= 6,1872xC^{0.9557}$
Stevia	0.8333	2.8924	0.9924	$S= 971,1xC^{0.8333}$
Sucralose	0.8055	3.2084	0.9771	$S= 1615,8xC^{0.8055}$

Table 4. Potency and sweetener power of sweeteners sucralose, stevia, xylitol and erythrirol

Sweetener	(%) Equivalente of 16% of sucrose	Sweetener potency
Sucralose	0.03	534.43
Stevia	0.05	282.06
Xylitol	15.47	1.03
Erythritol	25.77	0.62

The table 4 shows the power function of each sweetener compared to sucrose. Sucralose is the sweetener that presented the higher sweetener power (534.43), followed by stevia (282,06), xilitol (1.03) and erythritol (0,62). The concentration of sucralose to have the same sweetnes of 16% of sucrose in petit Suisse with oat is 0.03, followed by stevia (C= 0.06), xylitol (C= 15,47) and erythrtol (C= 25,77).

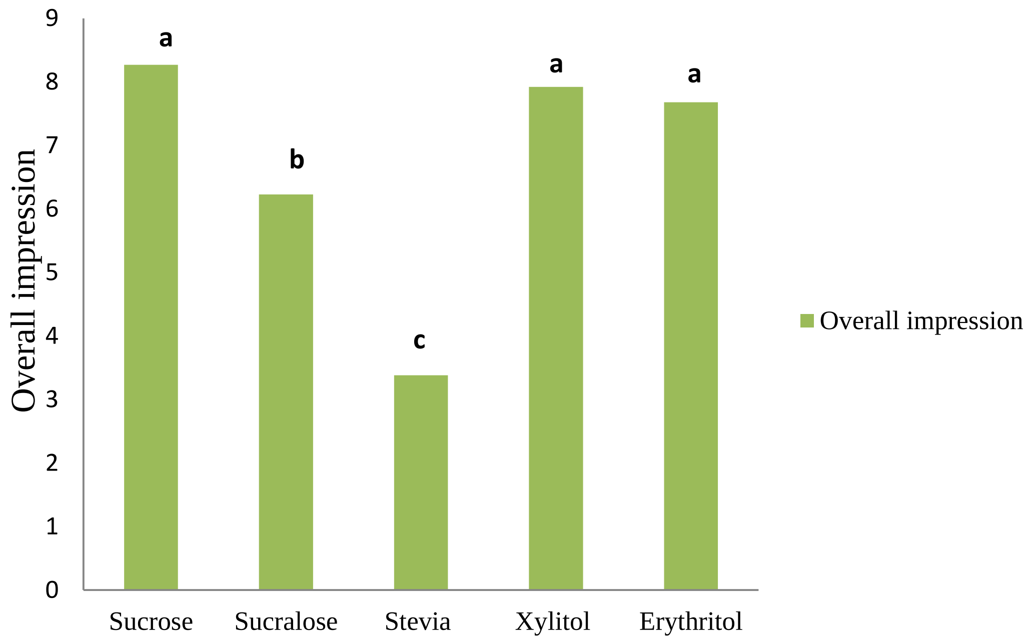
Figure 3. Correspondence analisys of sucrose, sucralose, erythritol, xylitol and stevia.



The figure 3 is a projection of correspondence analisysfor the samples of petit suisse cheese with oat and diferent sweeteners. The samples varied 96.06%% due to the main component, while the samples varied only 2,21% relative to the secondary component. Therefore, 98.27% of the variation of the main components regarding the parameters of the CATA test, which demonstrates an excellent explanation of the variation occurred between the samples. Xylitol presented a more similar behavior to sugar, and erytritol presented a behavior more similar to sucralose. The samples sweetened with these sweeteners presented acidity, sweetness, oat and milk flavor, essential sensorial characteristics of petit suisse.

However, these sweeteners did not show aftertaste, bitterness, mint, metallic taste or chemical-like sensation. In addition, the xylitol, erythritol and sugar samples showed the highest marks in the overall impression analysis (figure 4), showing no significant difference between them. Sucralose was different from sucrose at 5% significance level. Otherwise, stevia was highlighted by aftertaste, bitterness, metallic tast and chemical-like sensation. In addition, it obtained the lowest overall impression score according to the panelists, indicating that it is the sweetener less accepted by the panelists to be used in petit Suisse with added oats.

Figure 4. Global acceptance of sucrose and diferent sweeteners (sucralose, stebia, xylitol and erythritol)



Means followed by equal letters for each petit Suisse with oat sweetend with different sweeteners do not differ from each other at the 5% level by the Scott-Knott test.

Discussion

Acceptance test

The addition of oat in petit Suisse cheese aimed to increase the nutritional and sensorial acceptance of this cheese by all ages, considering this cheese is most consumed only by children (Prudencio et al. 2008). The panelists showed higher preference in the overall impression for the samples with 3% and 6% of oat in the acceptance test. The amount of 6% was choosen due tothe healthy and technological benefits of this cereal. Oat contain dietary fibers that are important to gut health (Brouns et al. 2017). Besdides, oat is a source of B-glucan (3-8g/100g), that has functional properties and health benefits (Sayanjali et al. 2017, El Khoury, 2011). When added to food, B-glucan display a good hability of thickening properties, to form gel at low concentrations, and it is associated to health promotion (Souza et al., 2015) , which turns this cereal very appropriated for petit Suisse cheese. The attributes of flavor and texture had thehigher score by T2, which reinforce the use of 6% of oat in petit Suisse cheese.

Ideal sucrose for petit suisse with oat bran and sweetener potency of sweeteners

The high amount of sucrose used in petit suisse make necessary to invest in research to find substitutes for sucrose. The findings for ideal sucrose of petit suisse chesse with oat added was 16%, which is very similar to previus studies of ideal sucrose for strawberry petit suisse chesse (Souza et al. 2011; Esmerino et al. 2013). In this study, it was used four sweeteners generally recognized as safe (GRAS) by FDA. The amount of daily ingestion of the panelists respected the recommendation of each sweetener (FDA, 2015; Storey et al., 2007; Culbert et al. 1986). The sweetener power is influenced by the intrinsic characteristics of the product. The combination of ingredients used to formulate the petit Suisse with oat promotes an interaction between the sweeteners and the food ingredients, changing in the sweetener potency of the sweeteners (Reis et al. 2011). Although the literature shows the determination of equivalent of all sweeteners used in this study, it is important to determine also de ideal sucrose as the equivalent power of each sweetener considering there is no study of it for petit Suisse with oat.

Our results for equivalent power of each sweetener are aligned with Reis et al.2011, who found the sweetness equivalence of sucralose of 0.03% in yogurt; however the results are different from Palazzo and Bolini (2017) that investigated the equivalent sweetness in chocolate ice cream using sucralose (0.0169%) and stevia (0.0874%). The different results demonstrated the changes in sweetener perception for different milk products. The power sweetener of Erythritol and xylitol are in accordance with the literature (Grembecka, 2015).

Cata and global acceptance

Xylitol

Xylitol is a polyol derived from xylose (Santos et al. 2015) that exists in a very low quantity in fruits and vegetables, i.e. plums, strawberries, cauliflower, and pumpkin (UR-REHMAN et al., 2015). This sweetener is a non fermented sugar that inhibits the metabolism of mutans streptococci, remain on a lower level as long as the consumption lasts (Soderling 2009). The addition of this sweetener in petit suisse a great substitute of sucrose, mainly for diabetic diets, because it does not increase in blood glucose considering it metabolism does not dependent on insulin (Emodi, 1978). Xylitol might have great applicability in the food industry and confectioneries, but the use of this sweetener as a food ingredient is still small because of its cost and lack of availability (Rafiqul and Sakinah, 2013, UR-REHMAN et al., 2015,Gueimonde, et al. 2016, Marghalani et al. 2017). Although when this polialcol is used as an ingredient it gives mint extract (Salli et al. 2017), this was not perceived by the panelists in petit Suisse cheese with oat added. This feeling of mint and fresh happens since it absorbs energy from the environment as it dissolves, causing a strong cooling effect in the mouth (Pirouzian et al., 2016). This result is very positive for this study, and showed the add xylitol in milk products does not interfere in the flavor of the product.Also, the sample with xylitol was not different from the sample sweeted with sucrose in the acceptance test. The findings showed good acceptance of xylitol as a replacer of sucrose. Also, adding oat improve the health benefits of petit Suisse, such as dietary fibers.Although the benefits of xylitol, the consume of this sweetener is limited by osmotic diarrhea. Only 25-50% of this sweetener is absorbed by the small intestine, resulting in substrate for bacterial fermentation in large intestine (Pirouzian et al., 2016), which may cause some intestinal discomfort. Considering the great acceptance of xylitol by the panelists and the health benefits of this sweetener, it is important to increase research to the ideal concentration of xylitol does not cause intestinal discomfort to guarantee the adequate use of this sweetener. Thus, more studies are needed on xylitol.

Erythritol

Erythritol is also a poliol extracted from natural sources that has a sweetness 60–70% that of sucrose and it is reported as a sucrose substitute with many advantages. Erythritol (1,2,3,4-butanetetrol) is a non-caloric C4 polyol made by fermentation (Grembecka, 2015) . Erythrtiol has a range of application in food product. The absorption of this sweetener is about 90%, which is excreted in the urine avoiding digestive problems (Boesten et al. 2015).

Erythritol showed a great acceptance for the panelists and it mint flavor was not perceived in thepetit Suisse with oat. Lin et al. (2010) showed that erythritol presented cooling sensation after used 50% of this sweetener in cookies, amount even higher than the used in this study. Akesowan (2009) showed the acceptance of erythritol in chiffon cake decreased as the amount of erythritol increased when it was used as sucrose replacer. However, the finding showed that erythritol did not differ of the sample with sucrose in the preference test. The use of erythritol seems to be adequated in petit suisse. Thus, the application in dairy products must be encouraged. Besides, Fuangpaiboon and kijroongrojana (2015), investigated the mixture of erythritol might be used with other sweeteners to replace sucrose in ice cream. As well as xylitol, this findings showed erythritol may used a sucrose replacer. However, this sweetener has a great advantage over xylitol, since the absorption of this erythritol is about 90%, which is excreted in the urine avoiding laxative side effects (Boesten et al. 2015). The health benefits and, so far, unawareness of adverse effects make this sweetener a good option for sucrose replacer.

Stevia

Stevia was used in petit Suisse cheese with oat added since it is a natural sweetener with zero calories (ŠIC ŽLABUR et al. 2016), adequate for diet with sucrose restriction and diabetic diet, with the possible to be applied for commercial purpose. Mielby et al. (2016) stated that the sweetener Stevia rebaudiana and the fibre β-glucan is a good combination for consumers that seek for health, since stevia is a natural non-nutritive sweetener and β-glucans have been related to various health benefits. However the sensory acceptance of this sweetener was lower compared to other sweetenes. The findings showed the mains attributes perceived by the consumers in petit Suisse sweetened with of stevia were chemical like sensation, bitterness and aftertaste. Narayanan et al. (2014) found that that consumers of yogurt sweetened with stevia are influenced by sweetness and sourness. The difference in results might be due to the amount of stevia in each product, since consumers of petit Suisse likes a higher perception of sweetness in the product, then the aftertaste increase with higher amount of stevia. Consequently, the perception of the sweeteness was significantly less ($p<0.05$) for stevia than for other sweeteners. The findings are aligned with Guggisberg et al. (2011) who found that the perception of bitterness and metallic taste in yogurt sweetened with stevia was described by the panelists. Furlán et al. (2016) showed that chocolate sweetened with 100% of stevia did not had a good accepetance. However, with the combination of Stevia with sucrose or sucralose promoted an improvement of the sensory acceptability. Lisak et al.

(2012) who found that strawberry yogurt sweetened with stevia had lower scored compared to the mixture of sucrose and stevia.

Sucralose

Althgough sucralose be an artificial sweetener, this overall acceptance was higher than stevia, and presented significantly lower ($p<0.05$) aftertaste than stevia. The overall impression of sucralose was significalty lower than the samples sweetened with sucrose. This results is aligned with Palazzo and Bolini (2017) who found that the acceptance diet chocolate ice cream with sucralose is significantly lower ($P\leq0.05$) than samples sweetened with sucrose. Mittal and Bajwa (2012) showed that the replacer of sucrose by sucralose in milk drinks was the same acceptance that the samples sweetened with sucrose. Sucralose is approved globally for use in foods and beverages as a non-caloric sweetener (Magnuson et al., 2017). This nonnutritive and high intensity sweetener has proved to be noncarcinogenic (Berry et al., 2016) and its use should be equivalent to about 5 mg/kg body weight/day (FDA, 2015).

Conclusion

In conclusion, the addition of oat bran had a good acceptance by the panelist, which make this cereal a good option to be added in petit suisse. Considering petit suisse is more consumed by children, the increase in nutritional value by adding oat bran make this product more attractive by adult consumers. To decrease ingredients that increase the calories in the product is a tendency of the manufators. Sucrose replacers were studied aiming to find the preference of consumers by those ingredientes.Also, the sweetener potency showed that the interaction of sweetner and the other ingredientes in the petit suisse with oat, change a little the sweetener potency of each sweetner compared to the literature.The natural sweeteners erytritol and xilitol had the samen acceptance of sucrose, which make those sweeteners good option to sucrose replacer. Insteady, sucralose had less acceptance, followed by stevia. The aftertast of stevia make the acceptance of this sweetener very low compared to sucrose.

Acknowledgements

This work was financially supported by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES), Brazil.

Bibliografia

AKESOWAN, A. Quality of Reduced-Fat Chiffon Cakes Prepared with Erythritol-Sucralose as Replacement for Sugar. **Pakistan Journal of Nutrition**, v. 8, n.9, p. 1383-1386, 2009.

BERRYA, C. et al. Sucralose Non-Carcinogenicity: A Review of the Scientific and Regulatory Rationale. **Nutrition and Cancer,** v. 68, n. 8, p. 1247–1261, 2016.

BOESTEN, D.M.P.H.J. et al. A. 2015. Health effects of erythritol. **Nutrafoods**, v. 14, p. 3-9.

BRASIL. Ministério da Saúde.Resolução n° 196 de 10 de outubro de 1996.Aprova as diretrizes e normas regulamentadoras de pesquisas envolvendo seres humanos. Diário Oficial [da] República Federativa do Brasil, Brasília, 1996.

BROUNS, F. ; DELZENNE, N. ; GIBSON, G. The dietary fibers – FODMAPs controversy. **Cereal Foods World,** v. 62, n. 3, p. 98-102, 2017.

CAROCHO, M.; MORALES,P.; FERREIRA, I.C.F.R. 2015. Natural food additives: Quo vadis? **Trends in Food Science & Technology,** v. 45, n. 2, p. 284-295

CASTURA, J.C. et al. Temporal Check-All-That-Apply (TCATA): A novel dynamic method for characterizing products. **Food Quality and Preference,**v. 47, p. 79-90, 2016.

CADENA,R.S. et al. Comparison of rapid sensory characterization methodologies for the development of functional yogurts. **Food Research International**, v. 64, p. 446-455, 2014.

CULBERT, S.J. et al. Oral xylitol in american adults. **Nutrition Research,** v. 6, n. 8, p. 913-922, 1986.

EL KHOURY, D. et al. Beta Glucan: Health Benefits in Obesity and Metabolic Syndrome. **Journal of Nutrition and Metabolism,** p. 1-28, 2012.

EMODI, A. Xylitol: Its properties and food applications**. Food Technol**., v. 32, p. 20–32, 1978.

ESMERINO, E.A. et al. The influence of sweeteners in probiotic Petit Suisse cheese in concentrations equivalent to that of sucrose. **J. Dairy Sci.,** v. 96, p. 5512–5521, 2013.

FOOD DRUGS AND ADMINISTRATION**.**Additional Information about High-Intensity Sweeteners **Permitted for use in Food in the United States,** 2015.

FUANGPAIBOON, N.; KIJROONGROJANA, K. Qualities and sensory characteristics of coconut milk ice cream containing differente low glycemimnc index (GI) sweetener blends. **International Food Research Journal,**v. 22, n. 3, p. 1138-1147, 2015.

Furlán, L.T.R. et al. Development of free sugar white chocolate, suitable for diabetics, using Stevia and sucralose as sweeteners: study of the thermal degradation kinetic. **International Journal of Research in Advent Technology,** v. 4, n. 7, p. 49-57, 2016.

GASMALLA, M.A.A., YANG, R., HUA, X. Stevia rebaudiana Bertoni: An alternative Sugar Replacer and Its Application in Food Industry. **Food Engineering Reviews**, v. 6, n. 4, p. 150-162, 2014.

GREMBECKA, M. Sugar alcohols—their role in the modern world of sweeteners: a review. **Eur Food Res Technol,**v. 241, p. 1–14, 2015.

GUEIMONDE, L. et al. Supplementation of xylitol-containing chewing gum with probiotics: a double blind, randomised pilot study focusing on saliva flow and saliva properties. **Food & Function,** v. 7, p. 1601-1609, 2016.

GUGGISBERG, D.; PICCCINALI, P.; SCHREIER, K. Effects of sugar substitution with stevia, actilight and stevia combinations or palationse on rheological and sensory characteristics of low-fat and whole milk set yogurt. **International Dairy Journal,** v. 21, p. 636–644, (2011)

GUPTA, R., YADAV, V., RASTOGI, M. View on importance of natural sweetener, a zero calorie plant – stevia - having medicinal and commercial importance. **International Journal of Food and Nutritional Sciences**, v. 3, n. 3, p. 90-94, 2014.

Jentzer, J-B. et al. Response surface methodology to optimise Accelerated Solvent Extraction of steviol glycosides from Stevia rebaudiana Bertoni leaves. **Food Chemistry**, v. 166, p. 561-567, 2015.

LIN, S-D.et al.Effect of erythritol on quality characteristics of reduced-calorie danish cookies.**Journal of food Quality,** v. 33, n. 1, p. 14-26, 2010.

LISAK, K. Sensory Evaluation of the Strawberry Flavored Yoghurt with Stevia and Sucrose Addition. **Croatian Journal of Food Technology, Biotechnology and Nutrition**v. 7, p.39-43, 2012.

MAGNUSON, B.A.; ROBERTS, A.; NESTMANNE.R. Critical review of the current literature on the safety of sucralose. **Food and Chemical Toxicology,**v. 106, p. 324-35, 2017.

WALTERS, M. et al. Phenolic acids, avenanthramides, and antioxidant activity of oats defatted with hexane or supercritical fluid. **Journal of Cereal Science**, v. 79, p. 21-26, 2018.

MARGHALANI, A.A. et al. Effectiveness of Xylitol in Reducing Dental Caries in Children. **Pediatric Dentistry,**v. 39, n. 2, p. 103-110, 2017.

MIELBY, L.H. et al. Changes in sensory characteristics and their relation with consumers' liking, wanting and sensory satisfaction: Using dietary fibre and lime flavour in Stevia rebaudianasweetened fruit beverages. **Food Research International,** v. 82, p. 14-21, 2016.

MITTAL, S., BAJWA, U. Effect of fat and sugar substitution on the quality characteristics of low calorie milk drinks. J Food Sci Technol, v. 49, n. 6, p. 704–712, 2012.

Morais, E.C. et al. Development of chocolate dairy dessert with addition of prebiotics and replacement of sucrose with different high-intensity sweeteners. J**ournal of Dairy Science,** v. 97, n. 5, p. 2600-2609, 2014.

MORTENSEN, A. Sweeteners permitted in the European Union: safety aspects. **Scandinavian Journal of Food and Nutrition**, v. 50, n. 3, 104-116, 2006.

NARAYANAN, P.Use of just-about-right scales and penalty analysis to determine appropriate concentrations of stevia sweeteners for vanilla yogurt. **Journal of Dairy Science,** v. 97, n. 6, p. 3262-3272, 2014.

OVERDUIN, J. et al. Failure of sucrose replacement with the non-nutritive sweetener erythritol to alter GLP-1 or PYY release or test meal size in lean or obese people. **Appetite,**v. 107, n. 1, p. 596-603, 2016.

OZDEMIR, C. et al. The production of ice cream using stevia as a sweetener. **J Food Sci Technol,** v. 52, n. 11, p. 7545–7548, 2015.

PALAZZO A.B., BOLINI H.M.A. Sweeteners in Diet Chocolate Ice Cream: Penalty Analysis and Acceptance Evaluation. **Journal of Food Studies,** v. 6, n. 1, p. 1-13, 2017.

PIROUZIAN, H.R., PEIGHAMBARDOUST, S.H., AZADMARD-DAMIRCHI, S. Sucrose-Free Milk Chocolate Sweetened with Different Bulking Agents: Effects on Physicochemical and Sensory Properties. **Biological Forum – An International Journal**, v. 8, n. 2, p. 340-349, 2016.

PRIYA, K., GUPTA, V.R.M., SRIKANTH, K. Natural Sweeteners : A Complete Review. **Journal of Pharmacy Research**, v. 4, n. 7, p. 2034-2039, 2011.

PRUDENCIO, I.D. Petit Suisse Manufactured with Cheese Whey Retentate and Application of Betalains and Anthocyanins.**LWT - Food Science and Technology,**v. 41, p. 905–10, 2008.

RAFIQUL, I.S.M.; SAKINAH, A.M.M. Processes for the Production of Xylitol—A Review.**Food Reviews International**, v. 29, p. 127–156, 2013.

REIS, R.C. et al. Sweetness Equivalence of Different Sweeteners in Strawberry-Flavored Yogurt**. Journal of Food Quality**, v. 34, n. 3, p. 163–170, 2011.

SAYANJALI, S**.**et al. The effect of extrusion on the functional properties of oat fibre. **LWT - Food Science and Technology**, v. 84, p. 106-113, 2017.

ŠIC ŽLABUR, J. et al. Stevia rebaudiana Bertoni - A Review of Nutritional and Biochemical Properties of Natural Sweetener. **Agriculturae Conspectus Scientificus**, v. 78, n. 1, p. 25-30, 2013.

SOUZA, N.L. Functional, thermal and rheological properties of oat b-glucan modified by acetylation. **Food Chemistry,** v. 178, p. 243–250, 2015..

SOUZA, V.R. et al. Analysis of various sweeteners in petit suisse cheese: determination of the ideal and equivalent sweetness. **Journal of Sensory Studies,** v. 26, n. 5, p. 339-345.

STOREY, D. et al. Gastrointestinal tolerance of erythritol and xylitol ingested in a liquid.**European Journal of Clinical Nutrition,** v. 61, p. 349–354, 2007.

SUPRIYADI, S.; SISWANDONO, S.; YUWONO, M. Method development and validation for the simultaneous determination of stevioside, rebaudioside-a, rebaudioside c and dulcoside a contained in stevia rebaudiana bertoni using HPLC-ELSD. **International Journal of Pharmacy and Pharmaceutical Sciences**, v. 8, n. 9, p. 1-5, 2016.

UR-REHMAN, S. et al. Xylitol: A Review on Bioproduction, Application, Health Benefits, and Related Safety Issues. **Critical Reviews in Food Science and Nutrition,**v. 55, p. 1514–1528, 2015.

VASILESCU, R. et al. Sweeteners and metabolic diseases: xylitol as a new player. **Rom. Acad.,** v. 2, p. 125–128, 2011.

WILLIAMS, E.J..Experimental designs balanced for the estimation of residual effects of treatments. **Australian Journal of Scientific Research**, v. 2, p. 149-168, 1949

ZUMBÉ, A.; LEE, A.; STOREY, D. Polyols in confectionery: the route to sugar-free, reduced sugar and reduced calorie confectionery. **British Journal of Nutrition,** v. 85, n. 1, p. 31-45, 2001.