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DESENVOLVIMENTO E CARACTERIZAÇÃO DE BEBIDAS À BASE DE SORO DE LEITE

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Tecnólogo em alimentos

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DESENVOLVIMENTO E CARACTERIZAÇÃO DE BEBIDAS À BASE DE SORO DE LEITE

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ATA 111- REUNIÃO DE BANCA EXAMINADORA PARA DISCUSSÃO E JULGAMENTO DE TESE DE DOUTORADO.

Aos sete dias do mês de junho de dois mil e vinte e quatro, às 10h00min, reuniu-se a banca examinadora composta pelos professores: Dra. Marion Pereira da Costa (presidente), Dr. Marco Antônio Sloboda Cortez, Dra. Alini Tinoco Fricks, Dr. Adriano Gomes da Cruz e o Dr. Denes Kaic Alves do Rosário, com a finalidade de discutir, avaliar e julgar a tese intitulada: "Desenvolvimento e caracterização de bebidas à base de soro de leite", de autoria do doutorando **Madian Johel Galo Salgado**, orientando da professora Marion Pereira da Costa. Após a apresentação do trabalho por parte do doutorando, foram feitos os questionamentos e comentários pelos examinadores e cumpridas as exigências regulamentares à defesa de tese. O doutorando fez a exposição oral de sua aula durante 50 minutos e em seguida foi arguido por todos os membros. A Banca Examinadora concluiu que o doutorando teve sua defesa pública de Tese de Doutorado Aprovada. Contudo, tal aprovação e a diplomação estão condicionadas à entrega da versão final da tese e entrega do comprovante de envio dos artigos científicos oriundos da mesma. Tais documentos devem ser apresentados na Coordenação do Programa no prazo de sessenta dias corridos a partir desta data. Após os sessenta dias, o não cumprimento dos prazos resultará na solicitação do desligamento do aluno junto ao NAREP. Nada mais havendo a ser tratado, foram encerrados os trabalhos, sendo a seguir lavrada a presente ata, que após lida e achada conforme, foi assinada pela presidente da banca examinadora, em substituição às assinaturas dos demais membros, e pelo coordenador do programa. Salvador, 07 de junho de 2024.

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DADOS CURRICULARES DO AUTOR

Formado em Tecnologia de Alimentos pela *Universidad Nacional de Agricultura* (Honduras), com mestrado em Ciência de Alimentos e doutorado em Ciência Animal nos Trópicos, com enfoque na avaliação, pesquisa e desenvolvimento de produtos lácteos, na Universidade Federal da Bahia (UFBA). Ao todo são mais de 7 anos atuando como pesquisador em leite e derivados, desempenhando diversas atividades. Entre elas, pode se destacar a gestão e organização das atividades e do material utilizado nas rotinas de análises microbiológicas do Laboratório de Inspeção e Tecnologia de Leite e Derivados (LaITLácteos) da Universidade Federal da Bahia (UFBA), organização de eventos de extensão, orientação de estudantes de iniciação cientifica e estagiários, escrita de projeto de pesquisa e de extensão, organização e realização de análises sensorial e estudos de comportamento de consumidor e, colaboração na escrita de artigos científicos, fichas técnicas e capítulos de livros. Possui conhecimentos em análises físicas-químicas, microbiológicas e sensoriais de leite e derivados, bem como implementação de ferramentas de qualidade como BPF, BPO, POPs e APPCC. Além disso, participou como professor assistente nas aulas de Tecnologia de alimentos, Microbiologia de alimentos de origem animal, Tópicos em ciência e tecnologia de leite e carne e Inspeção e tecnologia de leite e derivados.

DEDICATÓRIA

A Deus todo-poderoso por me dar a sabedoria necessária e forças para seguir em frente neste caminho longo. Aos meus grandes amores, meus pais Madian e Iris, ao meu companheiro e parceiro, Pedro, minhas irmãs Madai e Fabiola, meu “frijol” Mateo, por estar sempre comigo e por serem a fonte de inspiração para continuar me superando dia após dia, são os mais importantes da minha vida.

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Como todo projeto grande, o doutorado não é realizado por uma única pessoa, e sim depende de várias bases solidas que permitam ter uma estabilidade. Ou seja, o doutorado não é só o que passa dentro dos laboratórios e dentro das salas de aulas, mas sim do que passa em todos os aspectos da vida de quem faz um.

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Quero agradecer as irmãs maravilhosas, Madai e Fabiola. Ainda que tivesse briga, sempre fomos, e até hoje somos, muito próximos. Obrigado por ser minhas confidentes e minha fonte de inspiração. Ao meu frijol. Obrigado *mi papi*, por trazer tanta felicidade e bons momentos para nossa família. Assim quero agradecer a meu cunhado Geovani, por sempre estar aí para apoiar nossa família.

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Em 2010 fui estudar na Escola Agricula Luis Landa onde tive grandes experiencias e foi fundamental para minha formação pessoal. Além disso, me ajudou a formar amizades que tenho até hoje. Agradeço a meus grandes amigos Lenin e Sammir, obrigado por todas suas conversas, bons momentos e claro, pela sua amizade.

Em 2013 entrei na Universidade Nacional de Agricultura, onde vivi durante 4 anos, os quais foram de grande aprendizado, muitos estudos no corredor, comidas instantâneas, risadas e bons momentos. Ainda, durante esses 4 anos formei grandes amizades, agradeço a meus grandes amigos Will, Mafer, Nairoby, Rebeca, Josue, Carmen e Tutu. Também gostaria agradecer ao Ing. Janio Borjas pela confiança por me dar uma bolsa de estudos.

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RESUMO

SALGADO, M. J. G. **Desenvolvimento e caracterização de bebidas à base de soro de leite.** 2024. 122 p. Tese (Doutor em Ciência Animal nos Trópicos) – Escola de Medicina Veterinária e Zootecnia – Universidade Federal da Bahia, 2024.

A crescente demanda por alimentos funcionais, nutritivos e produzidos de maneira sustentável impulsiona a busca por inovações na indústria alimentícia. Nesse contexto, a indústria tem adotado a produção de derivados lácteos à base de soro não apenas para valorizar esse subproduto, mas também para oferecer um alimento com significativo potencial nutricional e de fácil processamento. O objetivo deste estudo foi desenvolver bebidas à base de soro de leite de diferentes espécies (caprino, bubalino e bovino) acrescidas de polpas de frutas (morango, cacau e graviola) ou farinhas de origem vegetal (açaí, beterraba e hibisco), e caracterizar o perfil sensorial, as características físico-químicas e microbiológicas das bebidas. Inicialmente, foi investigada a viabilidade técnica da adição de polpa de morango, graviola e de cacau nas bebidas, utilizando parâmetros como o pH, análises microbiológicas e o perfil sensorial. Posteriormente, cinco tratamentos foram elaborados, incluindo um controle comercial e um experimental, e com adição de farinhas de açaí, beterraba e hibisco, e foram caracterizadas através de testes sensoriais de aceitação, *Just-About-Right* (JAR), *Check-All-That-Apply* (CATA) e intenção de compra. Logo, as bebidas com maior e menor índice de aceitação foram submetidas a avaliação do efeito das informações na percepção do consumidor. Avaliou-se, também, a influência da adição de diferentes proporções de farinhas no pH, atividade microbiológica, cor instrumental, sinérese e capacidade de retenção de água (CRA). Os resultados do trabalho técnico (Artigo 1) indicam que a adição de polpa de fruta diminuiu ($p < 0,05$) o pH, e aumentou ($p < 0,05$) a aceitação das bebidas frente ao tratamento controle. No segundo experimento (Artigo 2) os tratamentos com cacau a 100 % foram penalizados nos atributos aroma e sabor doce, e não foi observado efeito significativo ($p < 0,05$) na aceitação das bebidas em função das informações recebidas pelos consumidores. No terceiro experimento (Artigo 3) a adição das farinhas ($p < 0,05$) diminuiu o pH e a sinérese, porém, aumentou os parâmetros de cor (L^*, a^*, b^* e C^*) e a CRA no dia 1 de estocagem. Além disso, a adição de farinha de beterraba inibiu o crescimento bacteriano. Nesse sentido, pode-se concluir que, a adição de polpas de frutas e farinhas de origem vegetal na produção de bebidas à base de soro foi eficiente, devido ao incremento na sua aceitação, fácil produção e propriedades tecnologias.

Palavras chaves: Alimentos funcionais; CATA; subproduto lácteo; teste de percepção.

ABSTRACT

SALGADO, M. J. G. **Development and characterization of whey-based beverage**. 2024. 122 p. Dissertation (PhD in Tropical Animal Science) – Escola de Medicina Veterinária e Zootecnia – Universidade Federal da Bahia, 2024.

The growing demand for functional foods, rich in nutrients and produced in a more sustainable way, drives the search for innovations in the food industry. In this context, the industry has adopted the development of whey-based dairy products aimed to valorize this by-product, but also to offer a food with significant nutritional potential and low-cost production The aim of this study was to develop whey-based beverages from different species (goat, buffalo and bovine) with added fruit pulps (strawberry, cocoa and soursop) or plant-based flours (açaí, beetroot and hibiscus), and to characterize the sensory profile, physicochemical and microbiological characteristics of the beverages. Initially, the technical feasibility of adding strawberry, soursop and cocoa pulp to the beverages was investigated using parameters such as pH, microbiological analyses and sensory profile. Subsequently, five treatments were developed, including a commercial control and an experimental one, adding açaí, beetroot and hibiscus flours, and were characterized through sensory acceptance tests, JAR, CATA and purchase intention. Therefore, the beverages with the highest and lowest acceptance score were subjected to an evaluation of the effect of the information on consumer perception. The influence of different proportions of flours addition on pH, microbiological activity, instrumental color, syneresis and water retention capacity (WRC) was also evaluated. The results of the technical work (Article 1) indicate that the addition of fruit pulp decreased ($p < 0.05$) the pH, and increased ($p < 0.05$) the acceptance of the beverages compared to the control treatment. In the second experiment (Article 2), the treatments with 100% cocoa were penalized in the aroma and sweet flavor attributes, and no significant effect ($p < 0.05$) was observed on the acceptance of the beverages based on the information received by consumers. In the third experiment (Article 3), the addition of flours ($p < 0.05$) decreased the pH and syneresis, nevertheless increased the color parameters (L*, a*, b* and C*) and the WHC on day 1 of storage. Furthermore, the addition of beet flour inhibited bacterial growth. In this sense, it can be concluded that the addition of fruit pulps and flours of vegetable origin in the production of whey-based beverages was efficient, due to the increase in their acceptance, easy production and technological properties.

Keywords: functional Foods; CATA; dairy by-product; perception test.

RESUMEN

SALGADO, M. J. G. **Desarrollo y caracterización de bebidas a base de lactosuero.** 2024. 122 p. Tesis (Doctor em Ciencia Animal en los Trópicos) – Escola de Medicina Veterinária e Zootecnia – Universidade Federal da Bahia, 2024.

La creciente demanda de alimentos funcionales, nutritivos y producidos de forma más sostenible, impulsa la búsqueda de innovaciones en la industria alimentaria. En este contexto, la industria ha adoptado el desarrollo de productos lácteos a base de lactosuero destinados a valorizar este subproducto, pero también a ofrecer un alimento con un potencial nutricional significativo y una producción de bajo costo. El objetivo de este estudio fue desarrollar bebidas a base de lactosuero de diferentes especies (cabra, búfala y bovina) con adición de pulpa de frutas (fresa, cacao y guanábana) o harinas vegetales (açaí, remolacha y flor de Jamaica), y caracterizar el perfil sensorial, las características fisicoquímicas y microbiológicas de las bebidas. Inicialmente, se investigó la viabilidad técnica de añadir pulpa de fresa, guanábana y cacao a las bebidas utilizando parámetros como pH, análisis microbiológicos y perfil sensorial. Posteriormente, se desarrollaron cinco tratamientos, incluyendo un control comercial y uno experimental, adicionando harinas de açaí, remolacha y flor de Jamaica, y se caracterizaron a través de pruebas de aceptación sensorial, JAR, CATA e intención de compra. Por lo tanto, las bebidas con mayor y menor puntaje de aceptación fueron sometidas a una evaluación del efecto de la información sobre la percepción del consumidor. También se evaluó la influencia de diferentes proporciones de adición de harinas sobre el pH, actividad microbiológica, color instrumental, sinéresis y CRA. Los resultados del trabajo técnico (Artículo 1) indican que la adición de pulpa de fruta disminuyó ($p < 0,05$) el pH y aumentó ($p < 0,05$) la aceptación de las bebidas en comparación con el tratamiento control. En el segundo experimento (Artículo 2), los tratamientos con 100% cacao fueron penalizados en los atributos de aroma y sabor dulce, y no se observó ningún efecto significativo ($p < 0,05$) sobre la aceptación de las bebidas con base en la información recibida por los consumidores. En el tercer experimento (Artículo 3), la adición de harinas ($p < 0,05$) disminuyó el pH y la sinéresis, sin embargo, aumentó los parámetros de color (L^*, a^*, b^* y C^*) y la CRA. Además, la adición de harina de remolacha inhibió el crecimiento bacteriano. En este sentido, se puede concluir que la adición de pulpas de frutas y harinas de origen vegetal en la producción de bebidas a base de lactosuero fue eficiente, debido al aumento de su aceptación, fácil producción y propiedades tecnológicas.

Palabras clave: alimentos funcionales; CATA; subproducto lácteo; prueba de percepción.

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CAPÍTULO 3

Impact of plant-based flour addition on the quality and shelf life of whey-based cocoa beverages

LISTA DE SIGLAS:

ºC	Graus Celsius
BCC	Control commercial beverage
BCE	Control experiment beverage
BCO	Beverage with cacao pulp
BFA	Beverage with açaí flour
BFB	Beverage with beetroot flour
BFH	Beverage with hibiscus flour
BSO	Beverage with soursop pulp
BST	Beverage with strawberry pulp
BWP	Beverage without fruit pulp
CATA	Check-that-all-apply
CO_2	Dióxido de carbono
d	Days
DBO	Demanda Bioquímica de oxigênio
IBGE	Instituto Brasileiro de Geografia e Estatística
JAR	Just-About-Right
L	Litros
mL	Mililitro
MPN	Número mais provável
RTD	Ready-to-drink
UFC	Unidade de formação de colônias
v	Volumem

SUMÁRIO

Página

1 INTRODUÇÃO

A indústria láctea, tanto no Brasil quanto globalmente, tem enfrentado diversas mudanças devido a fatores como alterações nos padrões de consumo, maior demanda por derivados lácteos e, principalmente, pela implementação de normativas que facilitam a comercialização de produtos por empresas de pequeno porte. Tais medidas incentivam a econômica regional e fortalecem a agroindústria familiar (KUNDU et al., 2024; ALVAREZ et al., 2021). No Brasil, cerca de 98 % dos municípios possuem atividades vinculadas à produção de leite e derivados, o que contribuiu para que o país alcançasse a terceira posição mundial no setor, com uma produção anual de 34 bilhões de litros, conforme dados do Ministério da Agricultura e Pecuária (MAPA, 2024).

O soro de leite é o principal derivado do processo de fabricação de queijos, comumente considerado como resíduo pelas pequenas e médias indústrias, tendo como destino a alimentação animal ou o descarte, consequentemente, quando descartado de forma incorreta, resulta na contaminação de recursos naturais (ZAMAN et al., 2023; TUGUME et al., 2024). No entanto, alternativas como a concentração ou isolamento das frações proteicas do soro tem pouca viabilidade devido ao alto custo dos equipamentos necessários (SAR et al., 2022). Em contraste, alternativas como a microfiltração, *spray dry* e redução do teor de água pelo método de concentração são muito utilizadas como formas de reaproveitamento do soro, o que permite sua comercialização e fácil distribuição (LAVELLI & BECCALLI, 2022; DAMAR et al., 2020). Embora, propriedades como potencial antioxidante, anti-carcinogênica, anti-inflamatória têm sido relatadas demostrando o alto potencial do soro como alimento nutricional (MINJ & ANAND, 2020).

As bebidas lácteas são o produto lácteo resultante da mistura do leite (in natura, pasteurizado, esterilizado, ultra alta temperatura (UAT), reconstituído, concentrado, em pó, integral, semidesnatado ou parcialmente desnatado e desnatado) e soro de leite (líquido, concentrado e em pó), podendo ser fermentadas ou não e com adição de frutas ou vegetais (Brasil, 2005). Atualmente, no mercado é possível encontrar uma variedade de bebidas lácteas, desde as mais tradicionais como achocolatadas, até bebidas lácteas desenvolvidas diretamente para atletas de alto desempenho (AYED et al., 2023). Além disso, tem-se observado acrescente no mercado de bebidas conhecidas como prontas para consumo direto ou *ready-to-drink* (RTD) definidas como bebida não fermentada preparada a partir da mistura de porção comestível de fruta, açúcar, água e aditivos para consumo direto (RATHINASAMY et al., 2021). Com isso, maior potencial antioxidante e conteúdo de vitaminas assim como melhorar a aceitação os benefícios são observados em bebidas com adição de polpa de frutas (GUTIÉRREZ-ÁLZATE et al., 2023).

A aceitação do alimento pelos consumidores é influenciada por diversos fatores, incluindo culturais, sociais, idade e nível de conhecimentos sobre o alimento a ser consumido (JEONG & LEE, 2021). Nos últimos anos, a divulgação de pesquisas sobre como os ingredientes afetam a saúde do consumidor, principalmente, quando se fala de quais componentes têm efeitos negativos, aumentam a busca por alimentos com benefícios à saúde (DRAKE et al., 2023; BAKER et al., 2022; CRUZ et al., 2010), no entanto, essas tendências podem afetar, de forma significativa, a aceitação ou rejeição de um determinado alimento. Nesse sentido, o processo de desenvolvimento de produtos é essencial para as indústrias de alimentos, responsáveis pelo desenho, optimização e desenvolvimento (GUINÉ et al., 2020).

Fatores externos estão diretamente relacionados com a aceitação do produto que não dependem das características do produto em si, e sim da percepção de cada consumidor. A embalagem, qualidade, padrões de higiene, informação nutricional, e principalmente, o preço do produto, são considerados fatores decisivos na hora de escolher um alimento (APRILE & PUNZO, 2022). Além disso, o efeito de alguns movimentos coletivos na aceitação do alimento é cada vez mais evidente. Aspectos tais como processamento ecológico, sustentabilidade e o tratamento que o animal recebe, podem ser considerados fundamentais no mercado de alimentos (KETELSEN et al., 2020; SABBE et al., 2009). Nos últimos anos, com o crescimento do consumo de alimentos industrializados, observa-se também aumento na demanda por alimentos naturais. Alinhados a uma alimentação mais saudável, as bebidas com adição de frutas são vistas como uma opção natural, nutritiva e sustentável (VAN BUSSEL et al., 2022; VIDIGAL et al., 2011).

Nesse sentido, o presente projeto teve como principal objetivo desenvolver bebidas à base de soro de leite de diferentes espécies (caprino, bubalino e bovino) acrescidas de polpas de frutas (morango, cacau e graviola) ou farinhas de origem vegetal (açaí, beterraba e hibisco), e determinar o perfil sensorial, as características físico-química, microbiológica e avaliar o efeito da informação (de saúde e sustentabilidade) na percepção, aceitação do consumidor e na intenção de compra das bebidas de cacau desenvolvidas.

2 REVISÃO DE LITERATURA GERAL

2.1 SORO DE LEITE

A produção mundial de leite ultrapassa os 801 milhões de toneladas (FAO, 2018), com uma parte considerável destinada à fabricação de queijos, manteigas, iogurtes e bebidas lácteas, representando 37%, 30% e 33% do volume total de leite, respectivamente (CASALLAS-OJEDA et al., 2021). Assim, a indústria de leite e derivados tem apresentado um crescimento significativo nos últimos anos. Segundo Shahbandeh (2023), estima-se que, até 2028, o valor de mercado mundial da indústria de lácteos atinja aproximadamente de US$ 1243 bilhões. Este aumento deve-se, em grande parte, à crescente demanda por alimentos de fácil consumo e acesso. Os produtos lácteos, ricos em nutrientes como as vitaminas D, B5, B12, cálcio, fosforo e potássio, são importantes produtos prontos para consumo, e importante veículo de culturas probióticas e ingredientes prebióticos (YANG et al., 2023; HOMAYONI RAD et al., 2016).

O queijo é o principal produto lácteo pronto para consumo, sendo o mais produzido e consumido em todo o mundo. A indústria do queijo, com um consumo elevado na União Europeia, Estados Unidos e Rússia (RANGEL-ORTEGA et al., 2023; MACEÍN et al., 2019), conta com mais de 2000 variedades, classificadas conforme o método de coagulação, dessoragem, prensagem, salga e maturação (MCSWEENEY et al., 2017). Além disso, o mercado de queijos artesanais, produzidos geralmente por pequenos e médios empresas, tem incrementado nos últimos anos, contribuindo para a economia local (LAVELLI & BECCALLI, 2022; RANGEL-ORTEGA et al., 2023). Contudo, durante a produção de queijos, o leite é submetido a coagulação enzimática, na qual a proteína do leite (caseína) é unida com a fase gordurosa, que originará o queijo, logo ocorre a separação desses componentes da fase aquosa do leite (SAR et al., 2022).

Desta forma, o soro é o subproduto obtido a partir da fabricação do queijo. Este pode ser classificado, dependo do pH, em soro doce (pH 6 a 7) ou ácido (4 – 4,6) (JANIASKI et al., 2016; TRINIDADE et al., 2019; ROCHA-MENDOZA et al., 2021). O soro doce é obtido pela coagulação do leite com enzimas proteolíticas, como a quimosina, resultando em coalhada e um líquido translúcido de coloração esverdeada (PANGHAL et al., 2018). O soro ácido, por outro lado, provém da fermentação do leite com ácidos orgânicos ou bactérias ácido-láticas, que reduzem o pH até o ponto isoelétrico da caseína (JELEN, 2011; TRINDADE et al., 2019; ROCHA-MENDOZA et al., 2021). O soro doce é mais utilizado na produção de bebidas lácteas devido às suas características favoráveis, enquanto o soro ácido, com sabor mais ácido e alto teor de sal, é menos utilizado (CARVALHO, PRAZERES & RIVAS, 2013; ROCHA-MENDOZA et al., 2021). Considerando que 37% do leite mundial é destinado à produção de queijo e que são necessários 10 litros de leite para produzir 1 quilograma de queijo, deixando aproximadamente 9 litros de soro por quilograma de queijo produzido. Isso significa que cerca de 33,3% da produção mundial de leite é transformada em soro (JELEN, 2011; SABOKBAR & KHODAIYAN, 2016; SILVA, BUENO & RODRIGUES SÁ, 2017), totalizando mais de 266 milhões de toneladas de soro. No entanto, apenas 54% desse soro é processado e utilizado na indústria (LAVELLI & BECCALLI, 2022), enquanto o restante é frequentemente descartado sem tratamento adequado, podendo causar impactos ambientais (CORDEIRO et al., 2019).

2.2 COMPOSIÇÃO FÍSICO-QUÍMICA DO SORO DE LEITE

Cerca de 55 % dos sólidos totais do leite são encontrados no soro, que é caracterizado pelo seu alto conteúdo de lactose (4,02 %), proteínas (2,69 %), minerais (0,59 %) e vitaminas hidrossolúveis (SALGADO et al., 2023). O soro é considerado como um subproduto altamente diluído devido ao seu alto teor de água (93 %) e baixo conteúdo de sólidos totais (aproximadamente de 7 %) (TSAKALI et al., 2010). Entretanto, a composição final do soro pode variar dependendo de fatores como o processo de produção do queijo, a matriz de leite utilizada, a época do ano e a nutrição e estágio de lactação dos animais, como Trindade et al. (2019) destacaram.

Recentemente, o soro tem sido utilizado na indústria de alimentos para a produção de alimentos destinados a atletas, crianças e idosos (SILVA, BUENO & RODRIGUES SÁ, 2017). Parte da produção de soro também é empregada na alimentação animal (SILVA, BUENO & RODRIGUES SÁ, 2017). Isso devido às propriedades funcionais e tecnológicas das proteínas do soro (SABOKBAR & KHODAIYAN, 2016; SILVA, BUENO & RODRIGUES SÁ, 2017).

O soro é uma rica fonte de proteínas com propriedades funcionais e alto valor nutricional, especialmente devido ao seu alto conteúdo em aminoácidos essenciais, particularmente aminoácidos sulfurados, associados à atividade anticancerígena (DJURIC et al., 2004; YADAV et al., 2015; CORDEIRO et al., 2019). As proteínas do leite bovino são divididas em duas classes principais: as caseínas e soro proteínas, sendo β-lactoglobulina e a α-lactalbumina as principais soro proteínas, representando 65 % e 25 % do total de proteínas, respectivamente, além de outras como albumina de soro e imunoglobulinas. Outras proteínas, como lactoferrina, lisozima, glicomacropeptídeo, fosfolipoproteínas e lactoperoxidase, são encontradas em menor proporção (EL-HATMI et al., 2015).

As proteínas do soro são caracterizadas pela sua atividade nutricional e funcional, sendo importantes na saúde do consumidor pelas suas propriedades no controle da hipertensão, anticancerígenas, hipocolesterolêmica e antimicrobiana e na absorção de cálcio (SABOKBAR & KHODAIYAN, 2016). Elas possuem uma ampla variedade de grupos funcionais, que permitem a formação de estruturas secundárias complexas (α-hélice e β - folha pregada). aumentando as propriedades reológicas das bebidas (PANGHAL et al., 2018).

O perfil proteico do soro é rico em aminoácidos essenciais como isoleucina, lisina, fenilamina, metionina, treonina, leucina, histidina, triptofano e valina. Além disso, as proteínas do soro são caracterizadas pelo alto conteúdo de aminoácidos sulfurados como a metionina e cisteína, funcionam como agentes precursores no metabolismo do carbono do reforço celular e intracelular da glutationa, atuando como agentes preventivos de câncer (YASMIN et al., 2013; TEIXEIRA et al., 2019).

O soro é conhecido como bebida rica em eletrólitos, devido ao seu alto conteúdo de minerais como o cálcio, magnésio, fosforo e zinco. Esses minerais têm um papel na redução do risco de doenças como a aterosclerose, obesidade, diabetes e câncer ou mesmo doença de Alzheimer e HIV (YASMIN et al., 2013; PANGHAL et al., 2018). Também, a lactose presente no soro ajuda na absorção de magnésio e zinco, favorecendo o crescimento da microbiota intestinal, e o controle da diarreia. Em relação às vitaminas, entre o 55 e 75 % do total de vitaminas do leite são encontradas no soro, devido suas características hidrofílicas vitaminas como a B6, B12, ácido pantatênico, tiamina, ácido nicotínico, ácido fólico e ácido ascórbico durante a produção de queijo são transferidos ao soro (PANGHAL et al., 2018).

2.3 IMPACTO AMBIENTAL

O soro, devido ao seu alto conteúdo de sólidos totais, é considerado fonte significativa de poluição, principalmente pela sua elevada demanda bioquímica de oxigênio (DBO), que varia entre 30.000 e 60.000 mg de $O_2.L^{-1}$. Esta característica torna a poluição gerada pelo soro superior à do esgoto doméstico, uma tonelada de soro não tratado pode equivaler à poluição produzida por mais de 470 pessoas (COSTA et al., 2012; SIQUEIRA et al., 2012; SILVA, BUENO & RODRIGUES SÁ, 2017). Assim, as indústrias de laticínios, especialmente as de pequeno e mediano porte, são vistas como potenciais poluentes, devido ao elevado consumo de água e a geração de resíduos como o soro, que é a principal fonte de poluição nesse setor (SILVA, BUENO & RODRIGUES SÁ, 2017). O descarte inadequado do soro pode impactar negativamente o ambiente, afetando as características físico-químicas do solo, reduzindo o rendimento nas lavouras e, quando descartado em corpos d'água, prejudicam a vida aquática devido à sua alta DBO (BASANTES et al., 2020).

Confirmando este aspecto, o soro é utilizado na produção de fórmulas para bebês, assim como na produção de concentrados ou bebidas para atletas e idosos (BASANTES et al., 2020). No entanto, o alto teor de água do soro exige processos de secagem para aumentar o conteúdo de sólidos totais, o que eleva o custo do processo, dada a necessidade de instalação de plantas de processamento especializadas (SIQUEIRA et al., 2012; SILVA, BUENO & RODRIGUES SÁ, 2017). Conforme Trinidade et al. (2019) relataram, das indústrias de laticínios; 60 % utilizaram o soro de maneira integral; 13 % de forma parcial e; 27 % não utilizaram, optando por descartá-lo no sistema de efluentes ou doá-lo para alimentação animal. Dessa forma, desafios como a falta de conhecimento nas indústrias de menor porte e o alto custo de processamento do soro de leite dificultam o tratamento eficaz deste resíduo como um poluente.

2.4 UTILIZAÇÃO DO SORO DE LEITE NA INDÚSTRIA LÁCTEA

Os produtos lácteos têm sido amplamente utilizados como alimentos funcionais pela característica da matriz láctea que viabiliza a incorporação de diferentes ingredientes, além de ser considerados produtos de fácil consumo. Dessa forma, observa-se um aumento na produção e processamento do leite nos últimos anos (PANGHAL et al., 2018; BASANTES et al., 2020). Assim, a alimentação mundial tem passado mudanças recentemente, impulsionadas pela demanda por alimentos menos processados que ofereçam benéficos à saúde, como probióticos, prebióticos, compostos bioativos, vitaminas e minerais (SILVA et al., 2019; RIVERO, MOREL & SOSA, 2020). Paralelamente, alimentos ricos em gordura têm sido frequentemente evitados pelos consumidores, que preferem alternativas com baixo teor gordura, associados à redução do risco de doenças, principalmente obesidade e problemas cardiovasculares (COSTA et al., 2012). Portanto, empresas do setor lácteo, como a *Daily Dairy*, estão lançando produtos lácteos com alto teor de proteína e baixo teor de gordura, destinadas a consumidores ativos e conscientes quanto as questões de saúde. Esses produtos são promovidos como alternativas ricas em proteínas e de baixo teor de gordura (LYUBOMIROVA, 2023).

Nas últimas décadas, a utilização de soro como resíduo na produção de bebidas lácteas, concentrados de soro e em fórmulas para bebês tem ganhado um destaque no mercado mundial e principalmente no Brasil (GUEDES et al., 2013), devido a sua aceitação pelos consumidores, fácil processo de produção, e as propriedades tecnologias das proteínas do soro de leite, sendo que apresentam maior solubilidade, incremento da viscosidade, maior retenção de água e poder emulsificante (HENRIQUES et al., 2021). O que resulta em produtos com maior aceitação, elevado valor nutricional e baixo investimento, devido ao aproveitamento do soro, (SILVEIRA et al., 2015; SOUZA et al., 2019; TRINIDADE et al., 2019).

No entanto, o soro enfrenta desafios de aceitação devido ao seu alto teor de minerais, que podem acentuar o sabor salgado. Para contornar isso, pode-se tratar o soro de diferentes maneiras para melhorar a aceitação. Uma alternativa prática e eficiente é o processo de secagem ou concentração do soro, que envolve a remoção da água por meio de evaporadores a vácuo, seguida de um processo de secagem por pulverização (*spray dry*) (PEREIRA et al., 2015). Outra possibilidade é a utilização do soro na produção de queijos como a ricota, que envolve o aquecimento do soro a altas temperaturas, levando à desnaturação das proteínas termossensíveis (MANGIONE et al., 2023). Além disso, o soro pode ser empregado na fabricação de bebidas lácteas.

A produção de bebidas lácteas a base de soro se torna uma alternativa viável do ponto de visto econômico, utilizando um resíduo que geralmente é descartado, e do ponto de vista ambiental, evitando que esse resíduo chegue a rios e lagoas provocando grandes contaminações. A partir dos anos 1970 a utilização do soro na produção de bebidas tem aumentado. Estudos relatam um crescimento de mercados de $17,67 bilhões para o ano de 2025 (ZOTTA et al., 2020), o que tem trazido uma grande variedade de produtos tais como as bebidas lácteas fermentadas, achocolatadas, com adição de frutas, bebidas alcoólicas e principalmente bebidas com alto teor de proteína destinada para pessoas de alto performance.

No Brasil, aproximadamente, o 25 % do mercado de bebidas é ocupado pelas bebidas lácteas fermentadas produzidas por misturas lácteas. Segundo a legislação supracitada, as bebidas lácteas comercializados no Brasil podem estar constituídas até por 51 % de base láctea, o que permite ao mercado poder realizar substituição parcial do leite pelo soro (GUTIÉRREZ-ÁLZATE et al., 2023).

O soro é caracterizado pelo alto teor de lactose, se torna uma ótima opção na produção de bebidas fermentadas. Os gêneros *Lactobacillus* e *Streptococcus* são os mais utilizados na indústria de bebidas fermentadas, podem ser utilizadas como culturas isoladas ou em co-culturas com diferentes espécies de bactérias (GARCIA et al., 2020). A fermentação consiste, basicamente, na adição de bactérias ácido lácticas (BAL), que produzem ácido láctico pelo consumo de carboidratos reduzindo assim o pH do meio (COSTA et al., 2014). As BAL são conhecidas pelo seu metabolismo capazes de degradar proteínas, açúcares e lipídeos incrementando as propriedades tecnológicas, sensórias e nutricionais do produto, além de produzir compostos bioativos benéficos para a saúde do consumidor.

As bebidas lácteas podem ser produzidas a partir da adição de frutas tornando-se uma fonte rica em vitaminas e compostos bioativos. Diversos estudos têm usado polpa de frutas como manga (AHMED et al., 2023), acerola (ABDOLMALEKI et al., 2015; Costa et al., 2013), laranja (GOUDARZI et al., 2015; HONG et al., 2015; NASIR et al., 2016) morango (YERLIKAYA et al., 2012), maracujá (SADY et al., 2012), e açaí (THAKKAR et al., 2018), entre outras. Além de incrementar os benefícios na saúde, a adição de polpa de frutas aumenta as características sensórias das bebidas, o que incrementa a aceitação das bebidas por parte dos consumidores.

2.5 FLAVORIZANTES DE ORIGEM VEGETAL

A adição de flavorizantes de origem natural, como frutas e vegetais, é amplamente utilizada na indústria láctea, sendo empregada em leites fermentados, queijos, doce de leite e outros produtos. Além disso, é uma tendência crescente na indústria de alimentos, visando não só o aprimoramento do sabor, mas também o enriquecimento nutricional desses produtos. O tipo de matéria prima, fruta, vegetal ou cereal, são escolhidos com base em preferências regionais e características do produto lácteo, mas também levam em consideração seu perfil nutricional. Em contraste, além de providenciar um sabor único, diversos estudos têm demostrado o grande potencial nutricional, sendo assim, existe grande demanda pela adição de frutas, vegetais ou cereais, de fontes ricas em compostos antioxidantes, fibras dietéticas, compostos bioativos, vitaminas e minerais (SOUZA & MATTANNA, 2019; ARSLANER, SALIK & BAKIRCI, 2020).

A utilização de frutas e vegetais na formulação de bebidas lácteas representa uma estratégia importante na indústria alimentícia para atender às preferências de sabor dos consumidores, enquanto simultaneamente enriquece o perfil nutricional dos produtos. Esta abordagem é influenciada por uma variedade de fatores, incluindo preferências culturais e regionais desses ingredientes. Em regiões tropicais, por exemplo, frutas como manga e abacaxi são populares devido à sua abundância, sabor doce e refrescante. Essas frutas são não apenas apreciadas por seu sabor, mas também são valorizadas por suas propriedades nutricionais, como alto teor de vitaminas e antioxidantes. Em contraste, em regiões de clima temperado, frutas como maçãs, frutas silvestres e cerejas são comumente utilizadas. Estas frutas são conhecidas por seu sabor rico e perfil nutricional equilibrado, incluindo fibras, vitaminas e compostos fenólicos, que são benéficos para a saúde (YADAV et al., 2016; TSYGANKOV et al., 2018).

Por outro lado, a incorporação de ingredientes vegetais em bebidas lácteas pode apresentar desafios, como a necessidade de estabilizar o produto para evitar separação ou alterações na textura e cor, bem como a manutenção de sua vida útil. Além disso, o equilíbrio entre o sabor natural das frutas e vegetais com o perfil de sabor dos produtos lácteos é crucial para garantir a aceitação do consumidor. Apesar dos desafios, o uso de flavorizantes de origem vegetal, como polpa de frutas e farinhas dos resíduos do processamento agroindustrial, representa uma oportunidade significativa para inovação e desenvolvimento na indústria láctea, proporcionando a criação de produtos que não são apenas saborosos, mas também nutritivos e alinhados com as tendências contemporâneas de alimentação saudável e sustentável (GUTIÉRREZ-ÁLZATE et al., 2023).

2.5.1 Polpas de frutas

2.5.1.1 Cacau

Cacau (*Theobroma cacao L*), originário da América Latina, é e reconhecido mundialmente por ser matéria-prima para a fabricação de chocolate. O Brasil destaca-se como um dos principais produtores de cacau, sendo superado por países como Costa do Marfim, Gana, Indonésia, Nigéria e Camarões (DIAS et al., 2007; MACIEL et al., 2018). Devido à sua significativa relevância econômica, a produção de cacau representa uma das principais bases econômicas em estados brasileiros como Bahia (NUNES et al., 2020). A polpa de cacau conhecida por sua característica como mucilaginosa apresenta uma coloração branca, textura esponjosa que envolve os grãos da fruta de cacau. Estes grãos são submetidos à fermentação, processo essencial na produção de chocolate (KONGOR et al., 2016). No entanto, durante o processo de extração dos grãos de cacau, é liberado um líquido branco turvo, considerado um subproduto da fermentação de cacau (SOARES et al., 2022), e caracterizado pelo alto conteúdo, 9 a 13%, de em açúcares fermentáveis como a frutose, glicose, sacarose, ácido cítrico e diversos sais inorgânicos. Historicamente, a polpa de cacau tem sido empregada na elaboração de bebidas como vinho (DUARTE et al., 2010; DIAS et al., 2007), cerveja (NUNES et al., 2020) e kefir (PUERARI et al., 2012). Além disso, a polpa de cacau é caracterizada pelo alto conteúdo de compostos voláteis, que contribuem significativamente para a aceitação dos produtos nos quais é adicionada devido à sua palatabilidade e aroma agradável, favorecendo a preferência dos consumidores (BICKEL-HAASE et al., 2021).

2.5.1.2 Morango

O morango, *Fragaria x ananassa*, é um dos flavorizantes mais utilizados globalmente. Caracteriza-se por suas propriedades sensoriais agradáveis, que conquistam tanto crianças e adultos (NEWERLI-GUZ et al., 2023). Esta fruta é consumida de diferentes formas, incluindo seu estado natural, em geleias, sucos e processada como flavorizantes em iogurte, bebidas lácteas e sorvetes. Além de seu sabor atrativo, o morango é reconhecido como um alimento nutritivo, rico em vitamina C e folato, destacando-se pelo elevado conteúdo de compostos fitoquímicos (GIAMPIERI et al., 2012). Entre estes compostos, os polifenóis os especialmente as antocianinas, são encontrados em grande quantidade no morango.

No entanto, fatores como a origem, espécie, tipo de coleta e armazenamento vão afetar as características físico-químicas dos morangos (QADERI et al., 2022). As antocianinas estão relacionadas com diversos benefícios a saúdes como antioxidante, anti-inflamatório, anticancerígeno e antimutagênico (MORTAŞ & ŞANLIER, 2017). Segundo Giampieri et al. (2012), os morangos apresentam um teor de antocianinas variando entre 150 e 600 mg/kg de produto fresco, podendo ser identificados mais de 25 tipos diferentes de antocianinas (DA SILVA et al., 2007).

2.5.1.3 Graviola

A graviola, *Annona muricata*, originaria de América Central, entretanto, ganhou destaque significativo como um cultivo em países da América do Sul como Brasil, Colômbia e Venezuela (SANTOS et al., 2023). Essa proeminência deve-se à sua notável adaptabilidade aos climas tropicais. A polpa da graviola é reconhecida por sua cor branca e sabor distintamente doce e ácido, que a torna atraente aos consumidores.

A graviola é cientificamente valorizada pelo seu alto conteúdo de compostos fenólicos, os quais têm demonstrado potencial benéficos à saúde. Estes incluem propriedades antidiarreicas, antidiabéticas, antifúngicas, anti-hipertensivas, anticancerígenas e antimicrobianas. Além disso, suas propriedades antioxidantes têm sido comprovadas em estudos *in vitro* e são encontrados na polpa, folha, casca e a semente da graviola (VIRGEN-CECEÑA et al., 2019; SANTOS et al., 2023).

Diante dessas qualidades, a graviola tem sido o foco de diversos estudos que avaliam a utilização dos subprodutos da fruta produção de alimentos como bebidas lácteas (GUEDES et al., 2013), iogurte (LUTCHMEDIAL et al., 2004), sorvete (VIRGEN-CECEÑA et al., 2019).

Adicionalmente, no Brasil, a polpa de graviola é amplamente consumida na forma de suco (SANUSI e BAKAR, 2018).

2.5.2 Farinhas de origem vegetal

2.5.2.1 Açaí

O açaí, *Euterpe oleracea*, é uma fruta de origem amazônica, o Pará e o Amazonas são os maiores estados produtores de açaí, sendo responsáveis pelo 58,8 % e 41,5 % da produção nacional de açaí. A fruta é conhecida pela sua forma cilíndrica, cor roxa, tamanho entre 1 e 2 cm, constituída por 90 % de semente e 10 % de polpa (ALVES et al., 2022; DA SILVEIRA et al., 2023). Além disso, é conhecido como uma "superfruit", devido ao alto conteúdo de compostos bioativos como flavonóides, antocianinas e substâncias funcionais, como ácidos graxos insaturados, nesse sentido, esse fato tem ajudado a incrementar a demanda nacional, além de hoje ser consumido, como suco energético, em países de América do norte, Europa e países Asiáticos como China e Japão (LIU et al., 2023; DE LIMA et al., 2015).

Culturalmente, nos estados do norte do Brasil, o açaí é consumido como um acompanhamento alimentar, sendo misturado com proteínas e farinha de tapioca. No entanto, em outras regiões é consumido como em forma de sorvete, suco ou como suplemento alimentar (MENEZES et al., 2008; DE LIMA et al., 2015). Devido a sua composição, a indústria de açaí gera uma grande quantidade de resíduos, resultado da produção de sorvetes e sucos, conhecidos como "burra" com alto conteúdo de fibras, 47 %, lipídios 1,5 % e proteínas 6,6 %, oferendo uma oportunidade para a utilização do resíduo industrial na produção de alimentos (BORGES et al., 2021; ROMANI et al., 2022).

2.5.2.2 Beterraba

A beterraba (*Beta vulgaris L.*), originaria da Ásia e da Europa. É caracterizada pela coloração intensa vermelho-violeta, resultado do alto conteúdo de pigmentos denominados betalaínas, fenólicos metabólicos secundários que são encontrados no bulbo e nos talos da planta (SANTOS et al., 2016; SANTOS et al., 2020; OZCAN, OZDEMIR & AVCI, 2020). Além disso, a betalaínas apresentam atividade antioxidante, anti-inflamatórias e inibição da oxidação lipídica (OZCAN, OZDEMIR & AVCI, 2020). No entanto, as betalaínas são considerados compostos sensíveis a degradação, pelo que a extração deve ser realizada tendo em conta fatores intrínsecos como a atividade enzimática e conteúdo de metais, e fatores extrínsecos como o nível de oxigênio, pH e a luz (SANTOS et al., 2020). A beterraba é caracterizada pelo seu alto conteúdo de açúcar, glicose e frutose em menor quantidade, e de sacarose, sendo principal carboidrato. Dessa forma, a beterraba pode ser cultivada para extração de açúcar ou como planta hortícola ou forrageira, sendo comumente utilizada no preparo de saladas (SANTOS et al., 2016; CHHIKARA et al., 2019). Além disso, a beterraba destaca-se pelo alto conteúdo de vitaminas A, B1, B2 B5 e C, e minerais como o potássio, sódio, fósforo, cálcio, zinco, ferro e manganês, e depolissacarídeos como a pectina, celulose e hemicelulose, consideradas fontes de fibras dietéticas (SOUZA & MATTANNA, 2019; OZCAN, OZDEMIR & AVCI, 2020). Dessa forma a beterraba tem sido utilizada na produção de iogurte como corante (SANTOS et al., 2020) como adoçante (OZCAN, OZDEMIR & AVCI, 2020; OZDEMIR & OZCAN, 2020); sorvete de leite (SANTOS et al., 2016), em leite fluido como estabilizante da cor (GUNESER et al., 2016).

2.5.2.2 Hibisco

O hibisco (*Hibiscus sabdariffa L.*) é uma planta tropical selvagem da família Malvaceae, devido ao seu sabor, as flores da planta são amplamente consumidas em forma de chá, geleias, molhos, vinho e especiarias (CID-ORTEGA & GUERRERO-BELTRÁN, 2015; ARSLANER, SALIK, & BAKIRCI, 2020). As flores do hibisco são caracterizadas pelo alto conteúdo de compostos bioativos como o ácido polifenólico, flavonóides e antocianinas com alta atividade antioxidante, atuando no estímulo do sistema imunológico, incrementando a produção de citocinas (SU et al., 2019; MAHFUDH, HADI & SOLECHAN, 2020; ARSLANER, SALIK, & BAKIRCI, 2020), sendo assim associadas a redução de risco de diversas doenças cardiovasculares, doenças relacionadas a obesidade, diabetes, atividade carcinogênicas e imunomoduladores (ARSLANER, SALIK & BAKIRCI, 2020).

2.6 ANÁLISES SENSORIAL

Naturalmente, os animais são organismos curiosos, e fazem uso de seus sentidos para conhecer o seu entorno. Nos humanos não é muito diferente, desde o início da nossa vida utilizamos os sentidos para conhecer a textura, cor e sabor daquilo que é novo para nós. No entanto, não foi até o século 19 que a análise sensorial foi utilizada como ferramenta para avaliar a aceitação de produtos (DRAKE, 2007). A análise sensorial consiste em fazer uso de nossos sentidos para avaliar as características de um alimento e/ou material. Segundo a legislação brasileira, define a análise sensorial como “A disciplina científica usada para evocar, medir, analisar e interpretar reações das características dos alimentos e materiais como são percebidas pelos sentidos da visão, olfato, gosto, tato e audição” (ABNT, 1993). Nesse sentido, a análise sensorial é uma ferramenta importante no desenvolvimento e fabricação de alimentos que tem como objetivo otimizar processos, incrementar aceitação, definir formulações e definir o melhor custo-benefício no processamento (CHENG et al., 2022).

A análise sensorial, atualmente, pode ser considerada uma ciência multidisciplinar, que vem sendo utilizada em áreas como farmácia, psicologia, estatística, comportamento de consumidor e sociologia (CRUZ et al., 2010). E áreas como a tecnologia, fábrica de carros e materiais industriais também estão fazendo uso dessa ferramenta devido a seu grande impacto na obtenção de informações de percepção necessárias para otimizar o desenvolvimento de produtos (PENSE-LHERITIER et al., 2021).

Além disso, a análise sensorial também pode ser utilizada como ferramenta de avaliação da qualidade do alimento. Alguns fatores indicativos de degradações físico-químicas, microbiológicas, tempo de estocagem, e desvios no processamento podem provocar mudanças nas características finais do alimento, e permitem manter a padronização das características sensórias dos alimentos, sendo um fator importante na fidelidade do consumidor (TEIXEIRA, 2009).

Na análise sensorial são utilizados os sentidos do panelista, o seja, são avaliadas as respostas de expressões que o indivíduo demostrou no momento de experimentar o alimento, pelo que é considerado como um resultado subjetivo, pelo que é necessário converter esses resultados em dados quantitativos que possam ser avaliados pelo pesquisador (RUIZ-CAPILLAS et al., 2021).

Devido à natureza dos resultados, percepções individuais, apresentam grande variabilidade depende de fatores como o indivíduo, faixa etária, sexo, hábitos alimentares, ambiente e informações do alimento e podem afetar a aceitação do alimento (TUORILA et al., 2009). Além disso, outros fatores como seleção dos panelistas, tipo de treinamento, ambiente de realização do teste, distribuição e entrega da amostra e identificação das amostras, também podem incrementar a variabilidade de resultados (RUIZ-CAPILLAS et al., 2021). Nesse sentido, é importante definir o teste sensorial que mais se encaixe no nosso objetivo.

De forma geral, existem três tipos de teste de avaliação sensorial (Figura 1); os testes discriminativos, ou testes de diferenças, fornecem informações sobre aceitação entre duas ou mais amostras; testes de descritivos, fornecem informações qualitativas e quantitativas das amostras, ou seja, eles ajudam descrever as características sensoriais detalhadas das amostras, e utilizam provadores treinados; e testes afetivos de aceitação, fornecem informações sobre reações espontâneas, podem ser realizadas com avaliadores sem treinamento prévio, e são considerados os mais usados na avaliações de consumidor (DRAKE et al., 2023).

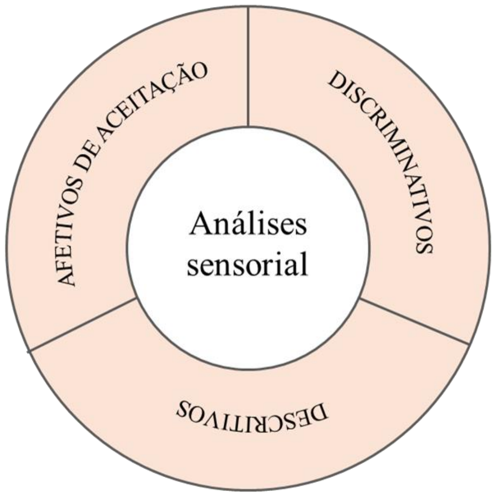

Figura 1. Classificação da análise sensoriais de alimentos.

Além disso, os testes podem ser classificados em objetivos ou subjetivos. Os objetivos são aqueles que dão resultados diretos e precisos, podendo os discriminativos e descritivos se encaixar. E os subjetivos, os testes afetivos se encaixam nessa classificação devido a que fornecem dados sobre a aceitação ou preferência de um produto (KEMP et al., 2011).

Métodos discriminativos também conhecidos como teste de diferença devido ao seu principal objetivo de determinar se existe diferencia entre 2 ou mais amostras, no entanto, também podem ser utilizados para determinar a concentração mínima de um ingrediente capaz de causar uma mudança no produto ou determinar o *Threshold*. Geralmente são utilizados quando é preciso a substituição de ingredientes, na otimização de formulação, mudanças no processo ou de embalagem e para determinar mudanças na vida estocagem (DRAKE et al., 2023; CRUZ et al., 2010). Dependendo do objetivo da pesquisa são necessários entre 25 e 50 consumidores para poder realizar o teste, no entanto, em quantidades pequenas de consumidores é requirido que os mesmos tenham experiência prévia. Os resultados são comparados utilizando tabelas binomiais (MEILGAARD et al., 2016).

São classificados em teste de diferença ou sensibilidade (Figura 2). Os testes de diferença são utilizados quando; quer se determinar a diferencias entre dois produtos e podem ser classificados em diferença geral ou descritores. No caso dos testes de sensibilidades são utilizados quando se quer determinar o *Threshold* de um novo ingrediente. No entanto, devido ao seu objetivo limitado, não podem ser utilizados em análises sensoriais mais complexos.

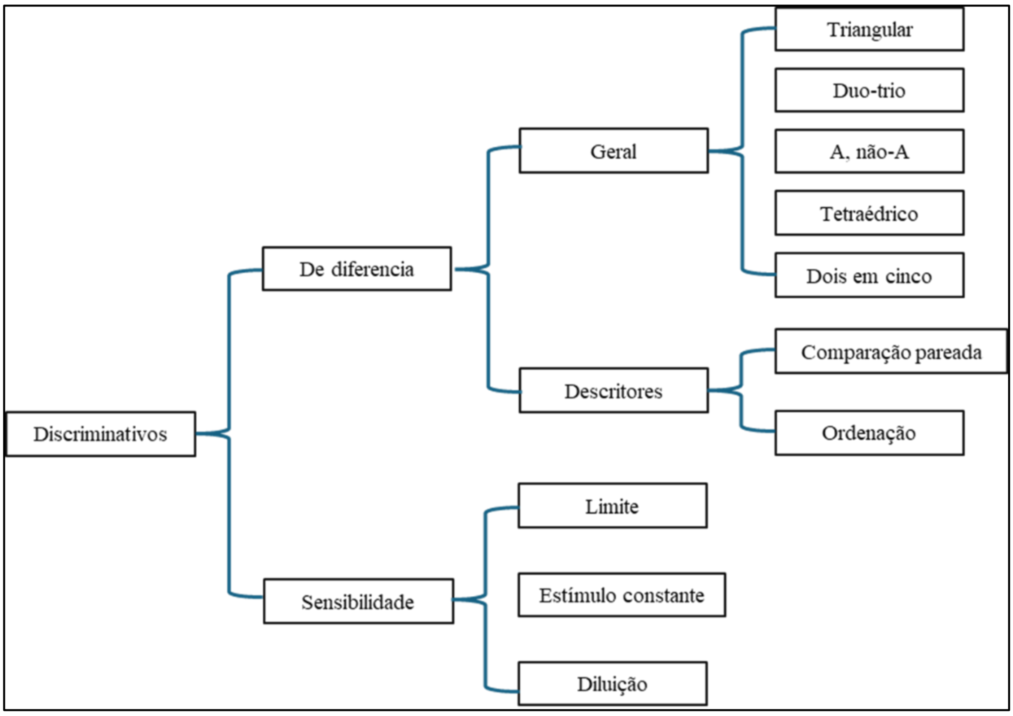

Figura 2. Métodos discriminativos e sua classificação.

Ao longo do tempo, as análises têm mudado e a cada dia são mais aprofundadas com o objetivo não só de estudar a afinidade do consumidor por determinado alimento, mas sim de avaliar como as características intrínsecas, ingredientes e o ambiente afeitam a percepção do consumidor. As técnicas de análises sensorial descritivas, conhecidas como análises deceptivas (AD). É uma ferramenta fundamental na quantificação e descrição das percepções humanas sobre as características de determinado alimento (DRAKE et al., 2023), além disso, ajudam na construção de perfil de sensorial do alimento, durante a performance é proporcionada uma descrição detalhada das intensidades de cada atributo, pelo que muitas vezes é requerido trabalhar com consumidores que tenham uma determinada experiência na avaliação sensorial (DELARUE, 2023). Nesse sentido, dependendo do nosso objetivo de estudo, ou seja, quais observações querem ser obtidas dos consumidores, as análises descritivas podem ser classificadas em três grupos (VALENTIN et al., 2012), métodos baseados em descrições verbais do produto (Figura 3); métodos baseados nas medições de semelhança ou diferenças entre produtos; e métodos baseados nas comparações de produtos individuais com uma referência ou conjunto de referências.

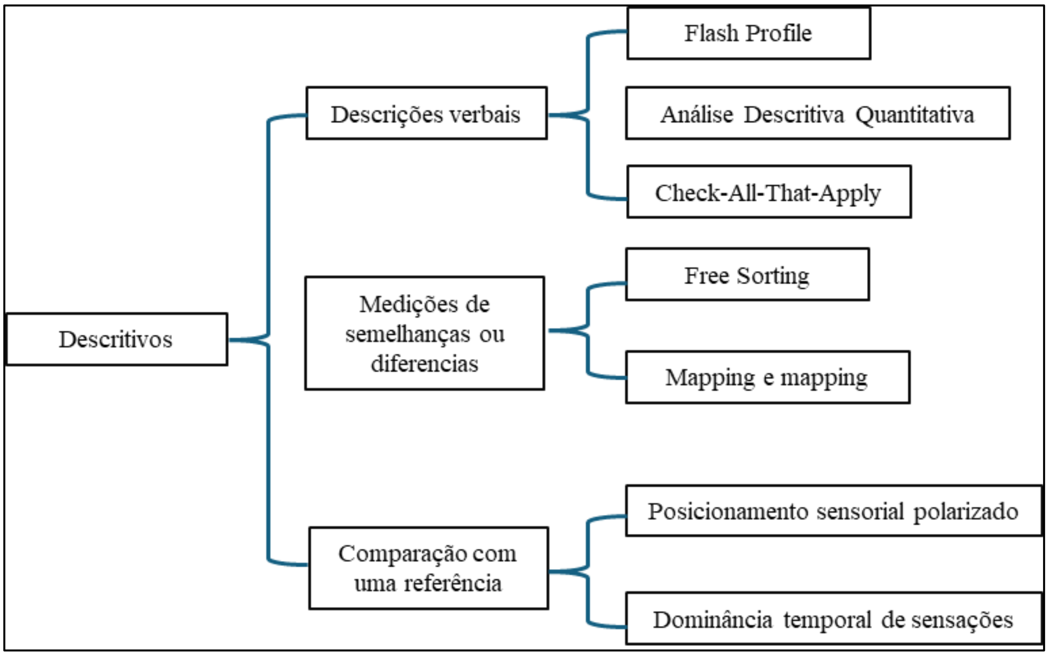

Figura 3. Métodos descritivos e sua classificação.

Além disso, os métodos descritivos se caracterizam por ser realizados por provadores treinados, de 4 a centos de horas de treinamento. No entanto, alguns métodos têm se observado eficientes ainda quando realizados por consumidores não treinados (DRAKE et al., 2023). A análise de CATA é um novo método de análise sensorial rápido e barato em comparação a outros métodos, que pode ser realizada por panelistas sem treinamento ou por panelistas treinados. Segundo Ares et al. (2010) o treinamento não tem efeito significativo nas respostas, o que facilita mais a sua realização. Consiste, basicamente, numa pergunta de múltipla escolha, e são proporcionadas uma série de palavras que ajudam descrever a amostra. O panelista, então, deve avaliar quais desses termos são necessários para descrever os atributos sensoriais da amostra. Nesse sentido, a análise CATA é caracterizada pela sua simplicidade e rapidez que são realizadas (ARES & JAEGER, 2023).

São necessários entre 60 e 90 consumidores para realizar a análises CATA. Isto, para poder ter uma maior variabilidade nas respostas. Além disso, é preciso não utilizar termos muito técnicos, e sim termos de fácil entendimento para o avaliador. Segundo Ares e Jaeger (2023) os termos devem ser de fácil entendimento e intuitivos, além de não ter uma quantidade grande de termos que possam confundir ou causar indecisão no consumidor. Nesse sentido entre 10 e 40 termos seria o ideal (JAEGER et al., 2015). Outro fator importante é a ordem dos termos, segundo Ares e Jaeger (2013) os termos devem ser colocados de forma aleatória, evitando colocar próximos termos que descrevam atributos semelhantes, o que pode causar uma descrição exagerada desses atributos. A análise CATA tem sido utilizada na área de lácteos como por exemplo em iogurte (CRUZ et al., 2013), sorvete (MUENPRASITIVEJ et al., 2022), bebidas lácteas (FARAH, ARAUJO & MELO, 2017).

A análise sensorial de alimentos tem se tornado uma parte fundamental no desenvolvimento de produtos. Sendo possível obter informações qualitativas e quantitativas, assim como conhecimentos sobre comportamento, gostos, intensidade dos ingredientes e informações individuais de cada consumidor. No entanto, e apesar dos grandes avanços que a ciência sensorial teve, os métodos afetivos ainda são altamente utilizados no processo de desenvolvimento de produtos tanto na indústria quanto na academia. Os testes afetivos podem ser divididos em testes qualitativos e testes quantitativos (Figura 4). Os testes qualitativos são utilizados para obter informações como percepções internas, necessidades ou expectativas do consumidor (LAWLESS et al., 2010). Com os testes quantitativos podem-se obter dois tipos de informações, de preferência (para determinar qual produto é mais preferido), e de aceitação (utilizando escalas para medir a aceitação) (DRAKE et al., 2023).

Os testes de preferência são utilizados quando se quer comparar 2 ou mais amostras, e é preciso indicar qual é a preferida. Nesse sentido, sempre será necessário indicar uma única resposta, ainda quando o provador não tenha gostado de numa das opções, pelo que o gosto pessoal de cada provador não é levado em conta. Os testes de preferência são classificados em testes de preferência pareada, são apresentadas duas amostras e o provador deve indicar a preferida; e teste de preferência por ordenação, onde mais de 2 amostras são apresentadas e o provador deve organizar as amostras conforme a sua preferência (MEILGAARD et al., 2016).

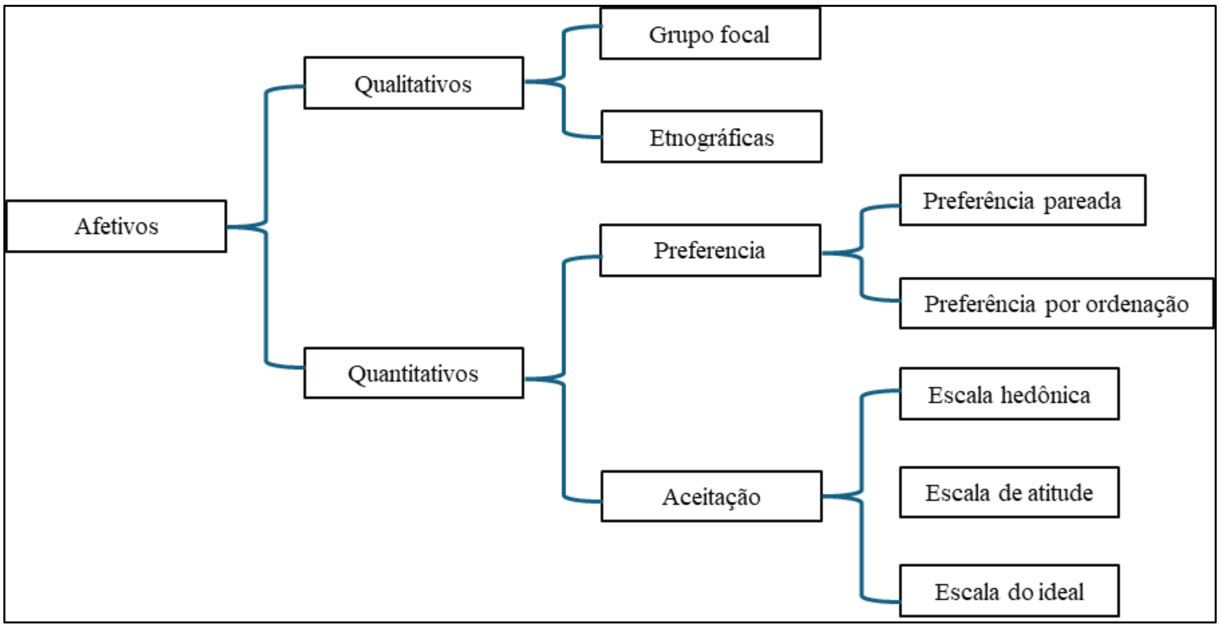

Figura 4. Métodos afetivos e sua classificação.

Os testes de aceitação sugiram na década dos 1950 com a criação da escala hedônica, o que permitiu poder determinar de forma quantitativa a opinião dos consumidores. É indispensável destacar a importância dos testes afetivos de aceitação no desenvolvimento de produtos. Permitem prever o comportamento do mercado, reduzir o número de tratamentos, comparar os produtos da concorrência, além de poder ser utilizado na otimização de processos e controle de qualidade (SCHIANO et al., 2017). Informações como a idade, origem, sexo e ambiente cultural dos consumidores são coletadas durante a avalição sensorial devido ao seu impacto nos resultados. Além disso, apesar de os consumidores não precisarem ter um treinamento, é importante que sejam consumidores frequentes do produto ou que represente o público-alvo (DRAKE et al., 2023). Segundo Drake (2007) recomendam evitar utilizar provadores treinados devido ao seu paladar mais crítico, o que pode não refletir o gosto do consumidor habitual. Durante a avaliação de aceitação são utilizadas escalas, podendo ser apresentadas de forma numérica, verbal, com desenhos e podem estar de forma horizontal ou vertical, considerando os provadores que avaliarão o produto (LAWLESS et al., 2010).

As escalas hedônicas são as mais utilizadas no desenvolvimento de produtos, podem ser estruturas, quando se tem referência numérica ou verbal, ou não estruturadas, quando são apresentados os pontos de os dois extremos. De forma geral, é utilizada uma escala hedônica estruturada de 9 pontos que vai de “não gostei extremadamente” até “gostei extremadamente”, representados por os números 1 e o 9, respectivamente. No entanto, podem ser utilizados outros valores como 5 ou 7 (CRUZ et al., 2010).

O teste de escala do ideal ou conhecido como *Just-About-Right* (JAR), é uma ferramenta utilizada para determinar a concentração ideal determinada pelos provadores. De forma geral, é utilizada uma escala dividida em duas partes iguais, mais que ideal e menor que o ideal, sendo o centro o ponto ideal (LÓPEZ OSORNIO & HOUGH, 2010). Nesse sentido, é importante utilizar várias concentrações do ingrediente a ser inserido para determinar a melhor concentração (DUTRA & BOLINI, 2014), de tal forma que o provador consiga determinar qual próximo do ideal está a intensidade de um determinado atributo, o teste de escala do ideal é considerado uns do método mais efetivo devido a suas características de confiabilidade, validade e simplicidade (DUTRA & BOLINI, 2014).

3 OBJETIVOS

3.1 OBJETIVO GERAL

Desenvolver bebidas à base de soro de leite de diferentes espécies (caprino, bubalino e bovino) acrescidas de polpas de frutas (morango, cacau e graviola) ou farinhas de origem vegetal (açaí, beterraba e hibisco), além de determinar o perfil sensorial, as características físico-química, microbiológica e avaliar o efeito da informação (de saúde e sustentabilidade) na percepção, aceitação do consumidor e na intenção de compra das bebidas de cacau desenvolvidas.

3.2 OBJETIVOS ESPECÍFICOS

- Avaliar o efeito da adição de frutas (morango, cacau e graviola), no pH e na contagem de microrganismos aeróbicos das bebidas à base de soro de leite cabra ao longo da estocagem.
- Determinar o efeito da adição de polpa de frutas (morango, cacau e graviola), nas características sensoriais, índice de aceitação e intenção de compras nas bebidas à base de soro de leite de cabra.
- Descrever e caracterizar o perfil sensorial de bebidas achocolatadas a base de soro de leite de búfala.
- Determinar o efeito da informação, saúde e sustentabilidade, na aceitação das bebidas achocolatadas a base de soro de leite de búfala.
- Estimar o efeito das farinhas de açaí, beterraba e hibisco em diferentes concentrações nas propriedades físico-químicas e microbiológicas das bebidas achocolatadas a base de soro.
- Determinar o tempo de vida de estocagem das bebidas achocolatadas a base de soro com adição de farinha de açaí, beterraba e hibisco em diferentes concentrações.

4 HIPÓTESES

A produção de bebidas à base de soro de leite de diferentes espécies (caprino, bubalino e bovino) com adição de polpa de frutas (morango, cacau e graviola) ou com farinhas de origem vegetal (açaí, beterraba e hibisco) é uma alternativa viável na utilização dos subprodutos da pequena e média indústria láctea. Além disso, a utilização de ingredientes fibras de origem vegetal modifica as características físico-químicas e microbiológicas das bebidas dando como resultados alimentos com maior potencial funcional.

5 CAPÍTULO 01:

Impact of fruit pulp addition on sensory acceptance of new goat whey beverages

Impacto da adição de polpa de fruta na aceitação sensorial de novas bebidas de soro de leite caprino

(Artigo técnico submetido ao periódico Revista do Instituto de Laticínios Cândido Tostes, ISSN (online) 2238-6416)

Impacto da adição de polpa de fruta na aceitação sensorial de novas bebidas de soro de leite caprino

Abstract

This study aimed to produce a new non-fermented goat whey-based beverages with the addition of fruit pulp. Four beverages were formulated: 1) without added fruit pulp (BWP), 2) with strawberry pulp (BST), 3) with soursop pulp (BSO), and 4) with cocoa pulp (BCO). Treatments were evaluated for total aerobic mesophiles counts and pH during the storage period (0, 6, 12, 18, and 24 days at 4 ± 1 ºC) as well as sensory acceptance (appearance, odor, color, flavor, viscosity, and overall impression), purchase intention, and Check-All-That-Apply (CATA). There was no difference in the total aerobic mesophiles counts between treatments on the first day of storage. The addition of fruit pulp decreased the pH of the beverages (BST, BSO, and BCO) and increased the overall acceptability compared to BWP. However, low purchase intention was observed. The Check-all-that-apply shows that the participants could identify differences between the treatments. Thus, fruit pulp could be used to produce goat whey-based beverages. Nevertheless, further studies should be conducted to improve and increase the acceptance of the new products.

Keywords: cocoa pulp, goat dairy products, sensory evaluation, soursop pulp, strawberry Pulp

Resumo

Este trabalho teve como objetivo produzir uma nova bebida não fermentada à base de soro de leite de cabra com adição de polpa de fruta. Foram formuladas quatro bebidas: 1) sem adição de polpa de fruta (BWP), 2) com polpa de morango (BST), 3) com polpa de graviola (BSO) e 4) com polpa de cacau (BCO). Os tratamentos foram avaliados quanto à contagem de aeróbicos totais (mesófilos) e pH durante o período de armazenamento (0, 6, 12, 18 e 24 dias a 4 ± 1 ºC), bem como na aceitação sensorial (aparência, odor, cor, sabor, viscosidade e impressão global) e na intenção de compra e *Check-All-That-Apply* (CATA). Não houve diferença na contagem do número de microrganismos aeróbicos (mesófilos) entre os tratamentos no primeiro dia de armazenamento. A adição de polpa de fruta diminuiu o pH das bebidas (BST, BSO e BCO) e aumentou a aceitabilidade geral em comparação ao BWP. No entanto, observou-se baixa intenção de compra. O CATA mostra que os participantes conseguiram identificar diferenças

entre os tratamentos. Assim, a polpa da fruta poderia ser utilizada para produzir bebidas à base de soro de leite de cabra. No entanto, mais estudos devem ser realizados para melhorar e aumentar a aceitação dos novos produtos.

Palavras-chave: avaliação sensorial, polpa de cacau, polpa de graviola, polpa de morango, produtos lácteos caprinos

Introduction

Goat milk can produce a wide variety of dairy products, including fermented products, such as yogurt and cheese (Ribeiro and Ribeiro 2010). In Brazil, has been an outstanding increase in goat milk production, according to IBGE (2017). The country reported a total production of 25.3 million liters of goat milk for 2017, with approximately 35% of this volume has been designated for cheese production. Consequently, cheese production generates a large amount of whey, an estimated 7.5 million liters of goat whey are generated annually as a residue (Galdino et al., 2020; Silva et al., 2017) commonly disregarded in countries such as Brazil (Lima et al. 2017).

Whey cheese has a slightly sweetened, acidic flavor, and cloudy appearance, from green to yellow (Jelen 2011). During cheese production, about 90 % of the volume and 55 % of the total nutrients of milk: soluble proteins, lactose, vitamins, minerals, and a minimal amount of fat, are found in the whey (Galdino et al. 2020; Giroux et al. 2018). Therefore, in developing countries, whey can be used as a raw material for the beverage development to provide a suitable destination for this residue with high biological value (Sousa et al. 2019).

Fruit pulp addition is commonly used to produce dairy beverages and can be an alternative to improve the taste and aroma of goat milk beverages (Costa et al. 2017). Strawberry (*Fragaria x ananassa Duch*) is the most widely used fruit in flavor milk due its color, aroma, flavor and its nutritional properties as good source of β-carotene, ascorbic acid, and phenolic compounds (Balthazar et al. 2019; Souza et al. 2019; Janiaski et al. 2016). Also, soursop (*Annona muricata*) pulp has high sensory overall liking, is rich in flavonoids, terpenoids, phenolic, and acetogenins with anti-inflammatory, antidiabetic, and antitumor activities (Dev and Joseph et al. 2021; Costa et al. 2017; Lutchmedial et al. 2004). Finally, the cocoa pulp (*Theobroma cacao L.*), considered as a by-product of the cocoa beans process, with high flavonoids content with antioxidant, anti-inflammatory, antimicrobial, and anticancer activity (Melo et al. 2017).

For these reasons, this work aimed to evaluate the effects of strawberry, soursop, and cocoa pulp addition to non-fermented goat whey-based beverages on the microbiological and pH parameters during 24 days of refrigerated storage at 4°C, as well as to assess the sensory evaluation (acceptance, purchase intention, and Check-all-that-apply) of the new products.

Materials and Methods

The goat whey used was obtained from the goat Coalho cheese with probiotic bacterial addition prepared at the Laboratório de Inspeção e Tecnologia de Leites e Derivados at the Federal University of Bahia (LaITlácteos/UFBA). The whey was filtered, pasteurized (65 ºC for 30 min) and kept refrigerated at 4 ºC until beverage production. Strawberry, soursop, and cocoa pulps (Brasfruit ®, Feira de Santana, Brazil) and sucrose (União®, São Paulo, SP, Brazil) were purchased from a local market in Salvador, Ba, Brazil.

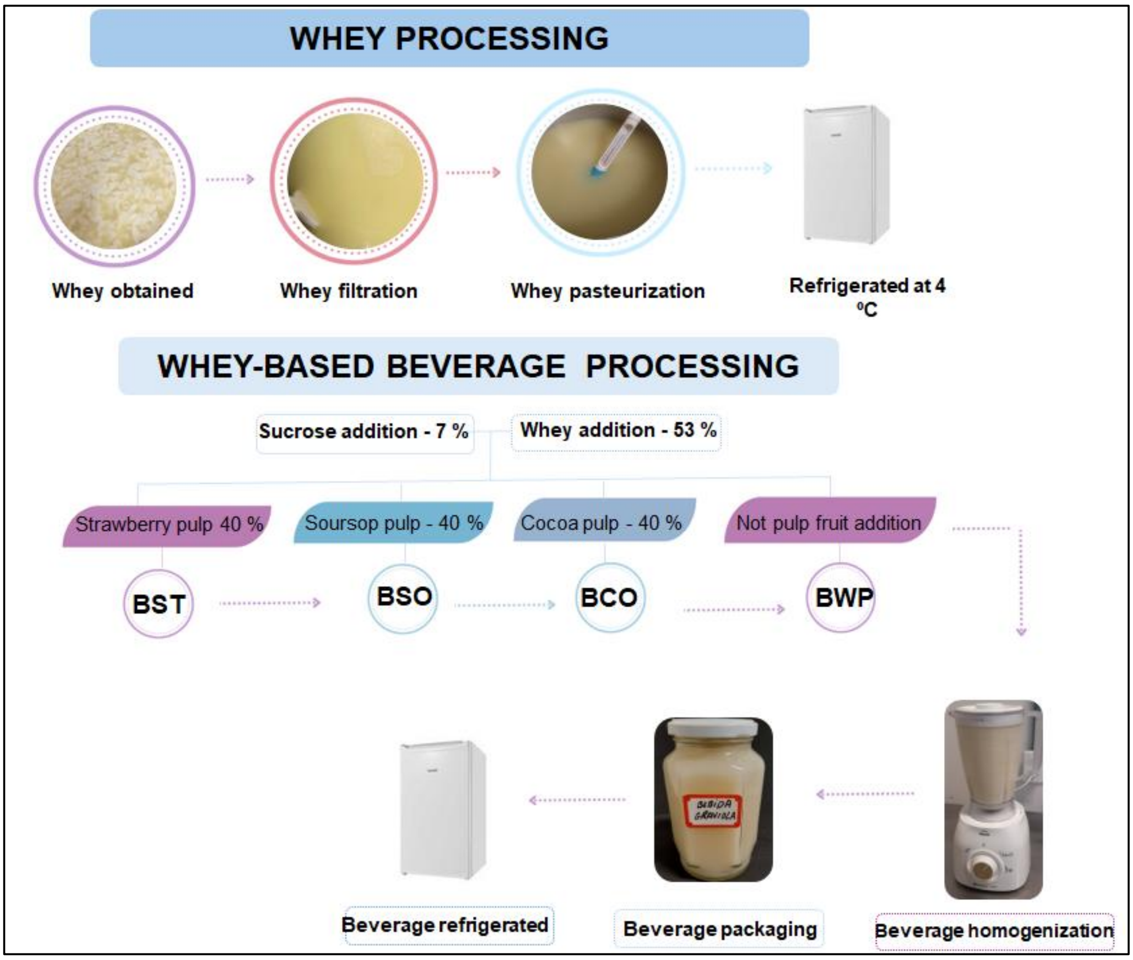

Figure 1. Flowchart of production process of goat whey-based beverages with fruit pulp addition.

The beverages were also prepared at the *Laboratório de Inspeção e Tecnologia de Leites e derivados* at the Federal University of Bahia (LaITlácteos/UFBA). Four different goat whey-based beverages were developed: beverage without fruit pulp (BWP); beverage with strawberry pulp (BST); beverage with soursop pulp (BSO); and beverage with cocoa pulp (BCO), Figure 1. All treatments contained whey (53 % v/v), sucrose (7 % w/v) of and fruit pulp (40 % w/v). Then the different ingredients were mixed for 3 minutes using a food processor (Philips Walita® RI7630, 600 W) for homogenization. After production, the whey-based beverages were placed in sterile glass bottles (2000 mL), refrigerated at 4 ± 1 °C, and stored for 24 days. The resulting mixtures were formulated following good manufacturing practices. This experimental procedure was conducted in triplicate (n = 3).

The raw material (whey, strawberry pulp, soursop pulp, and cocoa pulp) and the treatments (BWP, BST, BSO, and BCO) were submitted to microbiological analyze, including total aerobic mesophiles, total coliforms, thermotolerant coliforms, *Escherichia coli*, *Salmonella sp*., Enterobacteriaceae, yeasts and molds. Total and thermotolerant coliforms were evaluated through the most probable number technique (MPN) and *Escherichia coli* presence was assessed according to (APHA 2015). *Salmonella* isolation method was based on ISO 6579: 2002. Total aerobic mesophiles, Enterobacteriaceae, and molds and yeast counts were determined according to APHA (2015). Colony-forming units were counted and expressed as Log CFU.mL^{-1}. Total mesophiles count mesophiles were determined on days 0, 6, 12, 18, and 24 of refrigerated storage at 4 ± 1 °C.

The pH analysis was determined according to AOAC (2012) using a digital potentiometer (model K39-1014B, Kasvi®, SP, Brazil) for 24 days (0, 6, 12, 18 and 24 days) of refrigerated storage (4 ± 1 °C). All analyses (of each replicate) were performed in triplicate (n = 3).

Goat whey-based beverages (BWP, BST, BSO, and BCO) were evaluated for acceptance and purchase intention. Eighty untrained participants (58 women, 22 men) ranging from 18 to 69 years (mean = 26.71, SD = 9.67) were recruited at Federal University of Bahia. Consumers were recruited randomly, with specific regular consumption of yogurt or milk beverages and no food allergy. All samples (20 mL) were served in plastic containers (35 mm in diameter) at 8 ºC and coded with 3-digit random codes. For odor evaluation, all samples were served with caps. Participants were instructed to remove the cap only at the moment of odor analysis to minimize the loss of volatile compounds. Salt biscuit and filtered water at room temperature (25 ºC) were used to clean the taste between samples (Queiroz et al. 2017). Eighty untrained participants (58 women, 22 men) ranging from 18 to 69 years (mean = 26.71, SD = 9.67) were recruited.

For the acceptance test, the panelists assessed the appearance, odor, color, flavor, viscosity, and overall impression of each sample based on a 9-point hedonic scale (1 = extremely dislike and 9 = extremely like). The purchase intention was evaluated based on a 5-point category scale (1 = certainly would not buy, and 5 = certainly would buy) according to Costa et al (2017).

In addition, the participants found the check-all-that-apply (CATA) list with 35 terms. Every participant was asked to check all the terms that described the sensory characteristics of each treatment. The terms considered relate to the following attributes; for taste (15): bitter, too little sweet, too much sweet, too little typical strawberry, too little typical cocoa, too little typical soursop, typical strawberry, typical cocoa, typical soursop, goat whey, goat milk, residual fat, sweet, acid, sour; for aroma (6): typical goaty, sweet, acid, low intensity, mild, high intensity; for texture (9): too little liquid, too much liquid, too little viscous, too much viscous, too little gelatinous, too much gelatinous, creamy, sandiness, homogeneity about the beverage; and for appearance (6): translucent, opaque, bright, roseate, greenish and yellow.

The results of pH, total aerobic mesophiles count acceptance, and purchase intention were analyzed by one-way ANOVA and reported as means and standard deviation (M±SD). All ANOVA were subjected to Tukey's test at $P < 0.05$. Principal component analysis (PCA) of each sensory attribute data was performed. In CATA analysis was used Cochran's Q test for evaluate the frequency that each attribute was selected for each sample and statistical differences ($P < 0.05$). Correspondence analysis was performed to obtain a bidimensional representation of the relationship between samples and descriptors. All data processing was performed using the XLSTAT version 2013.2.03 statistical program (Addinsoft, Paris, France).

Results and Discussion

The pulps and whey presented the most probable number (MPN) of total and thermotolerant coliforms less than 3 MPN. Also, in all material the total aerobic mesophiles counts were below 5.18 log CFU.ml^{-1}(data do not show). No growth of Enterobacteriaceae was observed (< 1 log CFU.ml^{-1}), nor the presence of *E. coli* or *Salmonella sp*. Moreover, the counts for molds and yeats were 2.30 log CFU.mL^{-1} (strawberry pulp), 2.85 log CFU.mL^{-1} (soursop pulp), and 3.36 log CFU.mL^{-1} (cocoa pulp). All results are consistent with the current legislation (Brasil, 2018; 2020) that establishes the identity standards for fruit pulp and sweet/acid whey, respectively. Therefore, the raw material is of quality and suitable for beverage processing.

Food storage stability is usually reflected by the number of total aerobic mesophiles counts, in this case, all goat whey-based beverages were according to legislation for milk beverages (Brasil 2005) requires a maximum of 5.18 Log CFU.mL^{-1} on the initial day in contrast, there was no difference ($P > 0.05$) between treatments(Table 1), ranging from 3.89 Log CFU.mL-1 to 4.82 Log CFU.mL^{-1}, being below the maximum limit provided in the legislation. On the sixth day of storage, all treatments showed a reduction in the total aerobic mesophiles count, however, the lowest value was for the treatment BWP (3.00 Log CFU.mL^{-1}). On the 12th of storage, a significant increase ($P > 0.05$) in the values of total aerobic mesophiles count was observed for the BWP and BST treatments exceeded the maximum limit required to ensure product quality and safety. This is due some extrinsic factors such as pH and the concentration of antioxidant compounds can improve growth (Behnamnik and Vazifedoost, 2020).

For all treatments of goat whey-based beverage, the most probable number (MPN.mL^{-1}) of total and thermotolerant coliforms was lower than 3 MPN.mL^{-1}. Therefore, all treatments agreed with the microbiological standards designated by the legislation for milk beverages (Brasil 2005), which establishes the most probable number of 10 MPN mL^{-1} for total coliforms and 5 MPN mL^{-1} for thermotolerant. In this study, growth of enterobacteria was not observed (< 1 Log CFU.mL^{-1}), confirmed by the absence of *E. coli* and *Salmonella sp*. in all tested samples. The molds and yeasts growth presented values below 3.70 Log CFU.mL^{-1} in all goat whey-based beverages, and this set of results indicates satisfactory hygienic-sanitary quality, the efficiency of the pasteurization process, and good manufacturing practices used in the development of beverages., which establishes microbiological standards designated by the legislation for milk beverages (Brasil 2019). In addition, the choice of the dairy matrix can be highlighted since goat whey is characterized by protein compounds such as immunoglobulins, lactoferrin, lactoperoxidase, and lysozyme that have antimicrobial properties (Hernández-Ladesma et al. 2011).

The treatment with fruit pulp addition (BST, BSO, and BCO) presented a decrease in pH values compared to BWP (Table 1). This initial difference in pH value between the control and other treatments can be related to the pH of strawberry (3.56 ± 0.02), soursop (3.53 ± 0.03) and cocoa pulp (3.57 ± 0.03) used, these fruits are acid and present low pH values (Amariz et al., 2018). Similarly, Buriti et al (2014) observed pH decrease in beverages based on milk and goat whey with addition of guava and soursop pulp. Consequently, BST, BSO, and BCO treatments can be considered safer from a microbiological perspective due to a pH below 4.6. The low microbial count found in the beverage may be due to the low final pH of the beverages.

Table 1. pH and total aerobic mesophiles count average (means ± standard deviation) of goat whey-based non-fermented beverage during 24 days of storage at 4 ºC.

Parameters	Treatment[1]	Storage period (days)				
		0	6	12	18	24
Mesophiles Log10 CFU.mL-1	BWP	4.61±0.51^{A,a}	3.00±0.52^{A,b}	5.76±0.34^{A,a}	5.49±0.91^{A,a}	4.86±0.61^{A,a}
	BST	4.82±0.06^{A,ab}	4.09±0.06^{A,b}	5.28±0.06^{A,a}	5.16±0.06^{A,ab}	5.11±0.06^{A,ab}
	BSO	4.81±0.10^{A,a}	3.84±1.21^{A,a}	3.61±0.28^{B,a}	5.00±0.80^{A,a}	4.78±0.69^{A,a}
	BCO	3.89±0.72^{A,ab}	3.06±0.70^{A,b}	4.81±0.89^{A,a}	5.20±0.73^{A,a}	4.90±0.60^{A,a}
pH	BWP	5.10±0.01^{A,b}	5.19±0.02^{A,a}	5.18±0.02^{A,a}	5.16±0.01^{A,a}	5.04±0.02^{A,c}
	BST	4.16±0.00^{C,c}	4.28±0.01^{C,ab}	4.32±0.06^{B,a}	4.22±0.00^{C,b}	4.18±0.00^{C,bc}
	BSO	4.24±0.02^{B,bc}	4.31±0.00^{B,ab}	4.29±0.02^{B,a}	4.28±0.02^{B,b}	4.23±0.01^{B,c}
	BCO	4.27±0.00^{B,b}	4.30±0.00^{BC,a}	4.31±0.01^{B,a}	4.28±0.01^{B,b}	4.24±0.00^{B,c}

$^{A-B}$ Means in the columns followed by different capital letters differ among the treatments (Tukey test; P <0.05).
$^{a-c}$ Means in the lines followed by different lowercase letters differ among the storage times (Tukey test; P <0.05).
[1]BWP = control without fruit pulp; BST = with strawberry pulp; BSO = with soursop pulp; BCO = with cocoa pulp.

During the storage period, a decrease (P < 0.05) in pH was observed in all goat whey-based beverage treatments (Table 2). The BST treatment presented the lowest value (4.16) during the evaluated period compared to other treatments (BWP, BSO, and BCO). This behavior can be explained by the fruit's organic acid content such as: citric acid, acetic acid, malic acid, formic acid (Nunes et al. 2020; Koyuncu & Dilmaçünal, 2010). On the sixth day of storage, the BWP treatment had the highest pH value (5.19), and all other treatments also had an increase in pH (P <0.05) compared to the first day of storage. From the sixth to the twelfth day there was no statistical difference, remaining stable.

Table 2. Average of acceptance test attributes of goat whey-based non-fermented beverages.

Treatments[1]	Attributes[2]						
	Appearance	Odor	Color	Flavor	Viscosity	Overall liking	Purchase intention
BWP	4.17±1.97^{c}	4.49±1.80^{c}	4.49±1.87^{c}	3.24±1.93^{b}	4.33±1.84^{b}	3.47±1.92^{b}	1.54±1.97^{b}
BST	6.33±2.13^{a}	7.16±1.66^{a}	6.63±1.91^{a}	5.54±2.15^{a}	5.64±1.67^{a}	5.96±1.89^{a}	2.93±1.23^{a}
BSO	5.93±1.87^{ab}	6.71±1.75^{a}	6.01±1.72^{ab}	5.61±2.38^{a}	5.69±1.99^{a}	5.73±2.11^{a}	2.70±1.26^{a}
BCO	5.44±1.81^{b}	5.44±1.77^{b}	5.61±1.74^{b}	5.20±2.37^{a}	5.63±1.99^{a}	5.21±2.13^{a}	2.46±1.20^{a}

$^{a-c}$ Means in the columns followed by different capital letters differ among the treatments (Tukey test; P <0.05).
[1]BWP = control without fruit pulp; BST = with strawberry pulp; BSO = with soursop pulp; BCO = with cocoa pulp;
[2]The attributes (Appearance, odor, color, flavor, viscosity, and overall linking) were evaluated on a 9-point hedonic scale, whereas purchase intention was evaluated in a structured 5-point hedonic scale.

On the 18th day of storage, the pH value began to decrease until the end of storage. In contrast, on the 24th day, the lowest pH values were observed, with the BST treatment having the lowest pH value (4.18), there was a significant decrease in all treatments concerning the

18th day of storage. The reduction in pH may be associated with an increase in the count and metabolic activity of lactic acid bacteria (LABs) present or inoculated in dairy products, which are responsible for the production of lactic acid (Costa et al. 2016), since the beverages did not go through the sterilization process, it is possible that small accounting of LABs has resisted the pasteurization process, this can explain the presence of aerobic count observed during storage time. The results of the sensory evaluation of the goat whey-based beverage showed the treatment BWP was rejected by consumers and classified between "disliked slightly" to "disliked moderately" (Table 2).

In addition, no difference ($P > 0.05$) was observed in flavor, viscosity, and overall impression among treatments with fruit pulp addition (BST, BSO, and BCO), being classified between "neither like nor dislike" to "like slightly". This result can be related to their higher content in short and medium-chain fatty acid goat milk has been characterized with taste and odor intensified cause rejection by unusual consumers (Costa et al. 2017; Vieitez et al. 2016). Likewise, Caldeira et al (2010) report lower sensory acceptance in fermented beverage with a higher percentage of whey and 5 % strawberry pulp. However, an increase in the acceptance of appearance, odor, and color attributes was observed in the treatment with strawberry pulp due to the familiarity with dairy products with strawberry flavor. The sweet taste masks the characteristic flavor of the beverages. To improve the sensory acceptance of beverages, future tests should be developed to define the ideal percentage of sucrose (8 %, 10 %, and 12 %). Moreover, emulsifiers, thickeners and stabilizers can also be added to improve appearance, viscosity, and to avoid phase separation.

For the purchase intention, the treatment BWP had the lowest score (1.54) classified between certainly not buy and probably would not buy (Table 2). However, BST treatment had the highest average of 2.93. Among several fruit pulp additions used in yogurt's manufacture, the strawberry flavor is the most consumed and accepted (Balthazar et al. 2019).

According to the principal component analysis (PCA), PCs 1 and 2 accounted for 98.99 % of the total variation, 85.27 %, and 13.73 %, respectively (Figure 2). The sensory attributes of appearance, odor, color, flavor, viscosity, overall liking, and purchase intentions were all closely related to each other in the positive direction of PC1. The total aerobic mesophiles count, and pH showed a strong negative correlation with all sensory attributes of PC1 and had a high relationship with the BWP treatment, which was characterized by its higher pH compared to the treatments with fruit pulp and was being the lowest preferred one as shown in table 1, with the lowest score in all sensory attributes. PC2 is directly related to mesophiles and pH. The BST has higher relation with odor, color, appearance, purchase intention and overall linking, as shown in table 2, where the BST has the higher score in these sensory attributes. While BSO and BCO show a relation with flavor and viscosity, due to their intense typical taste.

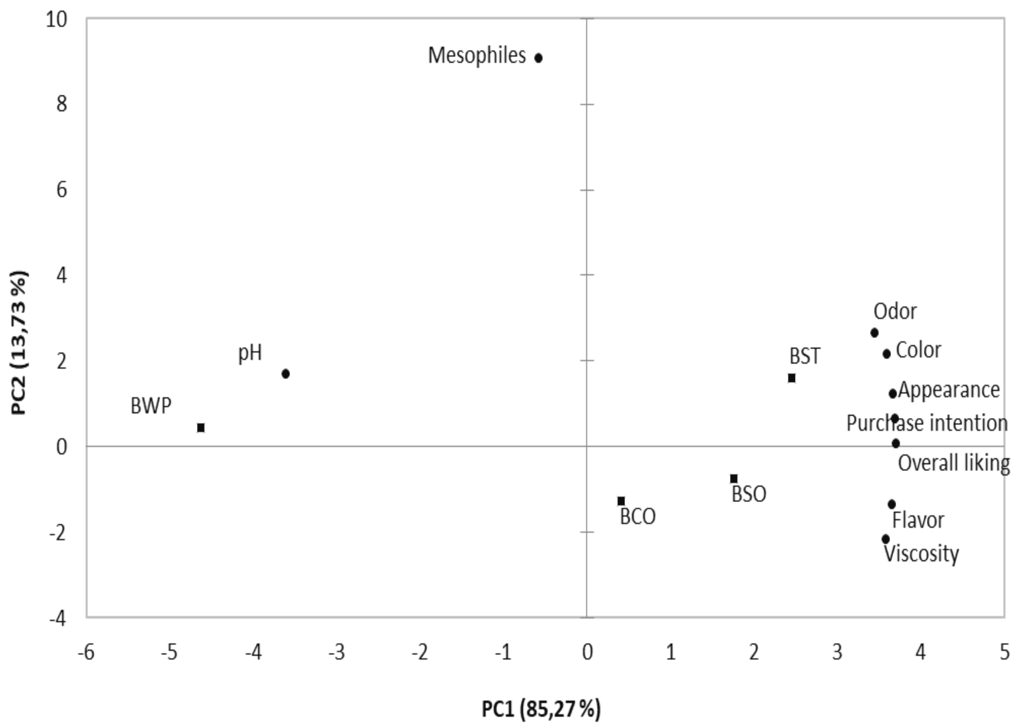

Figure 2. Principal component analysis is based on sensory, microbiological, and physical-chemical results.
Treatments: BWP = control without fruit pulp; BST = with strawberry pulp; BSO = with soursop pulp; BCO = with cocoa pulp.

The Q Cochran test results show that the frequencies of terms were indicated for each treatment, and 20 of the terms (57.1%) did not have significant differences ($P < 0.05$): bitter taste, too little sweet, too much sweet, goat milk taste, residual fat taste, sweet taste, acid taste, sour taste, acid aroma, low aroma intensity, mild aroma, too little liquid, sandiness, homogeneity with the beverage, translucent, opaque, bright, too much viscous, too little gelatinous, too much gelatinous (Table 3). Consequently, these terms cannot be considered responsible for accepting or rejecting products since there is no difference between the treatments.

On the other hand, a significant difference was observed in 15 terms (42.9 %), being them: too little typical strawberry taste, too little typical cocoa taste, too little typical soursop taste, typical strawberry taste, typical cocoa taste, typical soursop taste, goat whey taste, typical goat aroma, sweet aroma, high aroma intensity, too much liquid, too little viscous, creamy, roseate, greenish-yellow. Some of these characteristics are specific to each product, which indicates that the participants could identify differences between the treatments.

Table 3. Cochran's Q results values of frequency (%) of each attribute was indicated by consumers for goat whey-based non-fermented beverages.

Attributes	Treatments[1]				Value p
	BWP	BST	BCO	BSO	
Bitter taste	15.71	31.43	30.00	28.57	0.079
Too little sweet	32.86	32.86	27.14	25.71	0.581
Too much sweet	10.00	5.71	12.86	8.57	0.472
Too little typical strawberry taste	5.71	31.43	2.86	2.86	<0.001
Too little typical cocoa taste	18.57	4.29	8.57	4.29	0.003
Too little typical soursop taste	10.00	4.29	17.14	17.14	0.043
Typical strawberry taste	0.00	41.43	0.00	0.00	<0.001
Typical cocoa taste	4.29	2.86	20.00	5.71	<0.001
Typical soursop taste	1.43	2.86	28.57	57.14	<0.001
Whey of goat milk taste	50.00	12.86	17.14	18.57	<0.001
Goat milk taste	30.00	21.43	22.86	27.14	0.360
Residual fat taste	11.43	4.29	8.57	5.71	0.325
Sweet taste	15.71	24.29	25.71	21.43	0.384
Acid taste	15.71	25.71	22.86	18.57	0.314
Sour taste	11.43	5.71	5.71	5.71	0.351
Typical goat aroma	37.14	7.14	20.00	17.14	<0.001
Sweet aroma	12.86	44.29	15.71	32.86	<0.001
Acid aroma	11.43	5.71	5.71	5.71	0.372
Low aroma intensity	25.71	12.86	21.43	12.86	0.078
Mild aroma	11.43	24.29	22.86	27.14	0.095
High aroma intensity	10.00	24.29	7.14	25.71	0.001
Too little liquid	0.00	7.14	1.43	4.29	0.069
Too much liquid	60.00	32.86	27.14	37.14	<0.001
Too little viscous	38.57	22.86	30.00	21.43	0.017
Too much viscous	2.86	0.00	1.43	1.43	0.572
Too little gelatinous	30.00	22.86	20.00	21.43	0.359
Too much gelatinous	1.43	1.43	5.71	4.29	0.356
Creamy	2.86	15.71	22.86	17.14	0.003
Sandiness	4.29	0.00	4.29	0.00	0.112
Homogeneity in relation to the beverag(	8.57	18.57	12.86	18.57	0.222
Translucent	14.29	4.29	2.86	5.71	0.019
Opaque	17.14	8.57	18.57	15.71	0.314
Bright	20.00	30.00	24.29	30.00	0.281
Roseate	1.43	54.29	0.00	0.00	<0.001
Greenish yellow	25.71	1.43	7.14	11.43	<0.001

[1] BWP = control without fruit pulp; BST = with strawberry pulp; BSO = with soursop pulp; BCO = with cocoa pulp.

The bi-dimensional map of the correspondence analysis using the CATA technique (Figure 3) shows approximately 92.07% of the variance is explained in two dimensions, 64.54

and 27.53% in the first and second dimensions, respectively. It can be seen that the BWP treatment is related to the terms; too little typical cocoa taste, typical goaty aroma, too much liquid, whey of goat milk taste, too little viscous, translucent, and greenish-yellow. This fact may be because no fruit pulp was added to the high content of goat's milk whey used in its production. The BCO and BSO treatments were related to typical cocoa taste, typical soursop taste, and creamy. Likewise, in Table 3, it is observed that the participants had difficulty in differentiating them due to their consistency and soft taste on the palate (Zielinski et al. 2014). The BST treatment was characterized by a sweet aroma, too little typical strawberry taste, roseate, high aroma intensity, and typical strawberry taste.

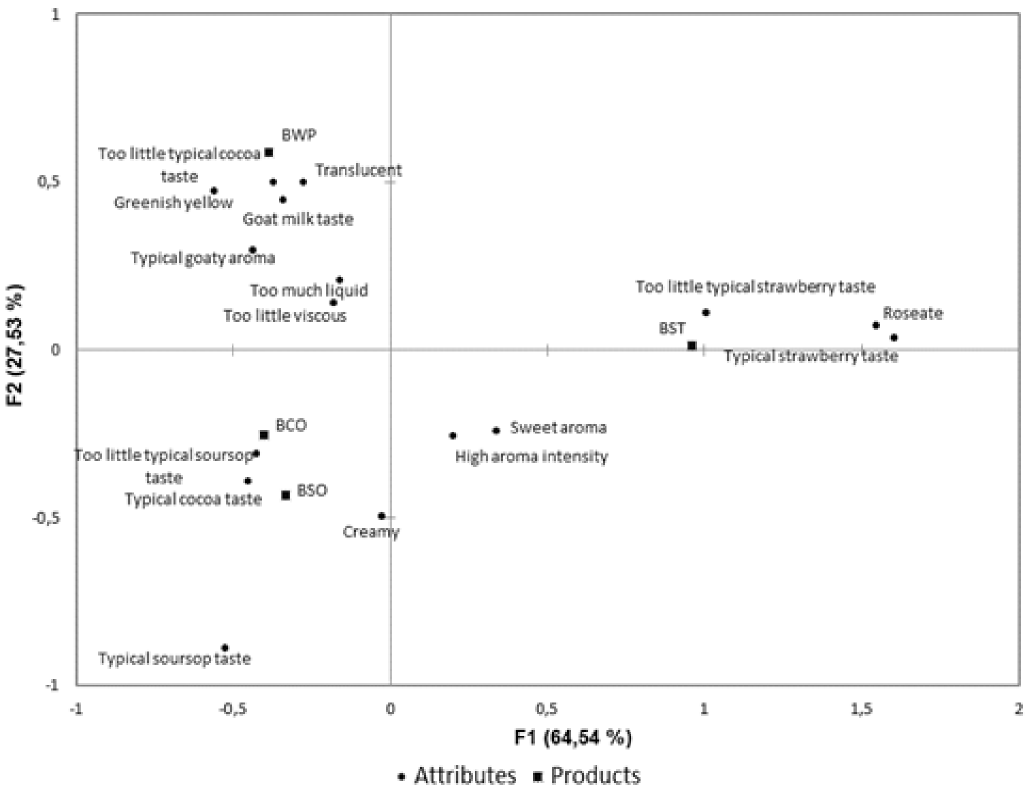

Figure 3. Correspondence analysis for the dimensions associated of check-all-that-apply (CATA) for different formulations of goat whey-based non-fermented beverages. Attributes. Treatments: BWP, without fruit pulp addition; BST = with strawberry pulp; BSO = with soursop pulp and BCO = with cocoa pulp (closed squares).

Conclusion

Production of beverages based on goat's milk whey could be considered an alternative to the use of dairy waste such as whey, due to its easy production and the requirement of elementary equipment. The addition of fruit pulps (strawberry, soursop, and cocoa) with low pH influences the pH of beverages improving the sensory attributes and allowing greater acceptance by consumers. In addition, the participants were able to identify the specific characteristics of each fruit pulp and, due to its greater familiarity, strawberry pulp treatments were more widely accepted. Thus, the preparation of beverages needs to be further studied, and different technological strategies should be tested, aiming to improve and increase the acceptance of new products.

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6 CAPÍTULO 02:

Buffalo whey-based cocoa beverages with unconventional plant-based flours: the effect of information and taste on consumer perception

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Buffalo Whey-Based Cocoa Beverages with Unconventional Plant-Based Flours: The Effect of Information and Taste on Consumer Perception

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Abstract: This study aimed to evaluate the addition of açaí, beetroot, and hibiscus flour on the sensory characteristics of a buffalo whey-based cocoa beverage and, second, to consider if health and sustainability claims could enhance consumer acceptance and purchase intention for the buffalo whey-based cocoa beverage. In this sense, five treatments were elaborated; BCC, the control with a commercial beverage formulation; BCE, the experimental control; BFA, with the addition of açaí flour; BFB, with added beetroot flour; and BFH, with the addition of hibiscus flour. The experiment was divided into two stages: In the first, the beverages were submitted to sensory analyses of acceptance (nine-point hedonic scale), purchase intention and just-about-right (five points), and check-all-that-apply (CATA). In the second stage, the beverages with the highest and lowest acceptance rates were taken, and they were subjected to the effect of sustainability and health information on consumer acceptance, purchase intention, and the CATA test using terms referring to emotions and feelings. The addition of flours decreased the beverage acceptance rate compared to the BCC treatment. The treatments were penalized in aroma and sweet taste. There was no effect on the type of information received by the consumer. Probably, the addition of high cocoa percentages can negatively affect the acceptance of products, as well as the use of flour with bitter flavors, due to the greater acceptance of sweeter products.

Keywords: consumer perception; buffalo whey; by-products; chocolate flavor; sustainability; beverage

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1. Introduction

Whey, a prominent by-product of the dairy industry, holds a significant position in annual dairy production, generating over 60 million liters. In the northeast region of Brazil, the production of coalho cheese stands out, obtained from rennet and matured for 10 days, and has a yield of approximately 1 kilo of coalho cheese per 10 L of milk, which generates approximately 9 L of whey [1]. However, this substantial volume of whey production has been accompanied by growing environmental concern since more than 50% of this valuable resource is traditionally discarded [2]. This wasteful practice has far-reaching environmental implications, ranging from water pollution to greenhouse gas emissions [3]. In light of these environmental challenges, there is a pressing need to reassess the role of whey in the broader context of sustainability within the dairy industry, which presents an opportunity for sustainable practices in the dairy chain, aligning with concepts such as the circular economy to mitigate environmental pollution [4]. One intriguing avenue that merits exploration is the utilization of buffalo whey, a specific variant with distinct attributes. Buffalo whey, while less commonly discussed in the literature, is an essential by-product of buffalo cheese production, which has a notable presence in certain regions, particularly in parts of Brazil [5]. This unique by-product may offer an alternative perspective on the sustainable use of whey, with potential economic and ecological advantages specific to regions where buffalo farming is prevalent. Therefore, as we consider strategies to mitigate the environmental footprint of the dairy industry, we should also examine how buffalo whey, among other types, can be harnessed efficiently.

The utilization of whey in the development of dairy products, such as beverages, presents a multifaceted advantage encompassing practicality, cost-efficiency, and effectiveness. These whey-based beverages, in addition to their inherent nutritional value, can serve as versatile carriers for an array of valuable bioactive compounds found in their constituent ingredients [6,7]. This approach not only elevates the overall appeal of dairy beverages but also aligns seamlessly with the growing consumer demand for functional and health-enhancing products [8]. For instance, the inclusion of purple plant-based ingredients in whey-based beverages can create dairy products that offer not only unexpected taste but also a valuable dose of antioxidants, potentially contributing to overall well-being.

Cocoa, *Theobroma cacao*, is the most used flavoring in the dairy beverage industry due to its flavor, preferred mainly by children [9]. It can be consumed as white chocolate, milk chocolate, and dark chocolate, containing between 70 and 99% cocoa [10]. It is associated with health benefits such as hypertension, due to its high polyphenol content and antioxidant activity, which has helped to increase the market for chocolates with a higher concentration of cocoa [11]. In addition to cocoa, other plant-based ingredients have been used in the food industry, such as flour.

The açaí agroindustry primarily utilizes the fruit's pulp, which constitutes a more 10% of the fruit, predominantly for the production of frozen and juice pulp. This process generates substantial waste, primarily comprised of seeds and fibers, posing a significant environmental concern. Exploring the biological potential of these açaí agroindustry residues, such as açaí flour, has opened up opportunities for the creation of sustainable biotechnological by-products. Açaí seed flour boasts a distinct chemical composition, leading us to hypothesize that this by-product not only retains the phenolic compounds of açaí but also contains other bioactive compounds. Thus, the addition of açaí flour to dairy beverages could potentially exhibit beneficial effects to consumers [12].

Hibiscus (*Hibiscus sabdariffa L.*) is a wild tropical plant from the Malvaceae family. Due to its flavor, the flowers or calyx of the plant are widely consumed in various forms, including hot or cold juices, jellies, sauces, wine, and spices [13,14]. These flowers are characterized by a high content of bioactive compounds such as polyphenolic acid, flavonoids, and anthocyanins, which exhibit strong antioxidant properties. They are known to stimulate the immune system and increase the production of cytokines, thereby reducing the risk of various cardiovascular diseases, obesity-related conditions, diabetes, and carcinogenic activity in addition to acting as immunomodulators [14–16].

Beetroot (*Beta vulgaris L.*) is renowned for its intense red–violet color, attributed to its high content of betalains, which are secondary metabolic phenolics found in the bulb and stalks of the plant [17–19]. Additionally, betalains exhibit antioxidant and anti-inflammatory properties while inhibiting lipid oxidation [17]. Beetroot is also characterized by its elevated sugar content, including glucose and fructose in smaller quantities, with sucrose as the primary carbohydrate source [18,20]. Moreover, it is rich in vitamins A, B1, B2, B5, and C, as well as minerals like potassium, sodium, phosphorus, calcium, zinc, iron, and manganese. It has found application as a coloring agent in yogurt production [18], a sweetener [17], an ingredient in milk ice cream [19], and a color stabilizer in fluid milk [21].

First, we have hibiscus flour, widely consumed in various forms such as tea, juice, and supplements. This natural ingredient is notably rich in anthocyanins, a class of flavonoids renowned for their antioxidant properties [22]. Furthermore, the açaí berry, a popular fruit known for its impressive array of health-promoting components, includes minerals, dietary fibers, phenolic compounds, flavonoids, tocopherols, and essential fatty acids such as linoleic and linolenic acid [23]. Furthermore, beetroot and its byproducts have emerged as promising options for individuals seeking to manage various metabolic disorders like hypertension, diabetes, insulin resistance, and kidney dysfunction [8]. Beetroot's therapeutic potential is attributed to its bioactive compounds, which have been studied for their positive effects on health. Therefore, incorporating hibiscus flour, açaí flour, and beetroot flour into whey-based beverages provides consumers with an accessible and enjoyable means of including these potentially beneficial compounds in their diets. This synergy between whey and various health-promoting ingredients underscores the versatility and potential of dairy beverages in promoting overall well-being.

The terms "sustainability" and "health" are concepts that are gradually becoming clearer to consumers. Consumers often associate sustainability with factors like reducing carbon footprints, avoiding preservatives, treating animals ethically, and using more natural ingredients. From their perspective, sustainability reflects a commitment to environmental and ethical considerations. Conversely, the industry tends to approach sustainability more from an agricultural perspective, focusing on sustainable farming practices and resource management [24]. This difference in interpretation highlights the need for clearer communication between consumers and the food industry regarding the concept of sustainability. Additionally, industries have introduced labeling systems aiming to simplify nutrition and health claims, recognizing that nutritional characteristics can be challenging for the average consumer to understand [25,26]. These labels offer a convenient way for consumers to make informed food choices, providing straightforward guidance on the nutritional content and potential health benefits of products. Through demystifying complex nutritional information, these labels empower consumers to make healthier food choices, promoting overall well-being.

However, it is crucial to strike a balance between sustainability, health, and consumer preferences when developing food products. Neglecting the sensory expectations and preferences of consumers can result in the introduction of products with limited market acceptance [27]. Therefore, during the product development phase, it is imperative to conduct sensory evaluations to gauge how consumers perceive the sensory characteristics of the products. Additionally, consumer acceptance is influenced not only by sensory attributes but also by non-sensory factors such as the brand's reputation, pricing, nutritional composition, and perceived health benefits [28–31].

In this context, the primary objective of this study was to assess the impact of incorporating açaí, beetroot, and hibiscus flour into a 100% cocoa buffalo whey-based beverage on its sensory characteristics. Understanding how these additions affect the product's sensory profile is crucial for ensuring that the beverage aligns with consumer expectations and preferences. Additionally, we aimed to investigate whether emphasizing health and sustainability claims could enhance consumer acceptance, purchase intention, and emotional responses to the buffalo whey-based cocoa beverage. In an era where consumers are increasingly conscious of their health and environmental impact, it is vital to explore how these factors influence their choices. Through highlighting the potential health benefits and sustainable aspects of the beverages, we aimed to determine whether these attributes could positively impact consumers' willingness to accept the product and their overall satisfaction.

2. Materials and Methods

2.1. Materials

The cow and buffalo milk whey was obtained using the coalho cheese production methodology [1]. The proximal composition of cow and buffalo whey is described in Table S1. Following extraction, the liquid whey underwent a filtration process, using fabric with micropores that prevented the passage of large curd particles, and was subsequently pasteurized at 65 °C for 30 min. It was then carefully refrigerated at 4 ± 2 °C until the beverage production phase. Açaí flour (Viva Nutureza Ind. de Produtos Naturais Ltda, Viva Nutureza®, Bahia, Brazil), xanthan gum (Sabor Leve, Leve Croc®, Parana, Brazil), xylitol (Natural Vitta Comercio De Variedades Ltda, Natural Vitta®, Bahia, Brazil), and cocoa powder (50% and 100%) (Nestlé Nordeste Alimentos e Bebidas Ltda,Bahia, Brazil) were purchased from a local natural product store in Salvador, Bahia, Brazil. Additionally, inulin (Neovita Foods Ltda, São Paulo, Brazil), beetroot powder (Natural Vitta Comercio De Variedades Ltda, Natural Vitta®, Bahia, Brazil), and hibiscus flour (Della Terra Comercio E Distribuidora De Produtos Naturais E Suplementos Ltda, Della Terra®, São Paulo, Brazil) were acquired from trusted online stores.

2.2. Cow and buffalo Whey-Based Cocoa Beverage Preparation Processing

The cow and buffalo whey-based cocoa beverage was processed at the Laboratory of Inspection and Technology of Milk and Derivatives at the Federal University of Bahia (LaITLácteos/UFBA). Five distinct variations of the cow and buffalo whey-based cocoa beverage were developed, including two types of control: a control variant reflecting the typical characteristics of chocolate beverages found in the local market (BCC) and a control variant with a new formulation (BCE). The remaining three variants consisted of a beverage with açaí flour (BFA), a beverage with beetroot flour (BFB), and a beverage with hibiscus flour (BFH). In the BCE, BFA, BFB, and BFH treatments, xylitol (3.5% *w*/*v*), inulin (2.5% *w*/*v*), 100% cocoa powder (7.5% *w*/*v*), and the respective flour (2.5% *w*/*v*) were incorporated and mixed with buffalo whey, 86.5% for BCE and 84.0% for BFA, BFB, and BFH, respectively. For the production of the commercial control (BCC), crystal sugar (3.5% *w*/*v*), xanthan gum (0.25% *w*/*v*), and 50% cocoa powder (7.5% *w*/*v*) were added and mixed with 88.75% cow whey. The resulting blends were formulated following good manufacturing practices and homogenized using a food processor (Philips Walita® RI7630, 600 W, Philips Do Brasil Ltda, São Paulo, Brazil). Subsequently, the buffalo whey-based beverages were packaged in sterile glass bottles (2000 mL) and refrigerated at 4 ± 2 °C until the next day to carry out sensory analysis. The beverages were subjected to microbiological analysis according to Brasil (2005) [32] to ensure the hygiene of the final product.

Table 1. Just-about-right (JAR) profile scores for the different formulations evaluated.

Attributes	BCC [1]	BCE	BFA	BFB	BFH
Amber color	3.02 ± 0.72^{a}	2.91 ± 0.69^{a}	3.04 ± 0.80^{a}	2.85 ± 0.96^{a}	2.89 ± 0.72^{a}
Brown color	2.97 ± 0.70^{bc}	3.11 ± 0.71^{ab}	3.39 ± 0.91^{ab}	2.73 ± 0.94^{c}	3.26 ± 0.74^{a}
Red color	2.78 ± 0.72^{b}	2.79 ± 0.74^{b}	3.00 ± 0.94^{ab}	3.93 ± 1.06^{a}	2.96 ± 0.78^{ab}
Sweet aroma	2.89 ± 0.83^{a}	2.44 ± 0.91^{b}	2.29 ± 0.88^{bc}	2.27 ± 0.92^{bc}	1.98 ± 0.89^{c}
Cocoa aroma	2.85 ± 0.78^{c}	3.30 ± 0.89^{a}	3.33 ± 0.91^{a}	3.23 ± 1.05^{ab}	2.89 ± 1.21^{bc}
Bitter aroma	2.93 ± 0.55^{c}	3.17 ± 0.74^{bc}	3.29 ± 0.84^{b}	3.32 ± 0.97^{b}	3.80 ± 1.07^{a}
Milk aroma	3.05 ± 0.77^{a}	2.59 ± 0.78^{b}	2.45 ± 0.90^{b}	2.44 ± 0.88^{b}	2.37 ± 1.01^{b}
Sweet taste	2.90 ± 0.79^{a}	1.96 ± 0.83^{b}	2.10 ± 0.91^{b}	1.93 ± 0.85^{b}	1.45 ± 0.70^{c}
Bitter taste	3.00 ± 0.50^{b}	3.24 ± 0.80^{b}	3.33 ± 0.89^{b}	3.25 ± 1.08^{b}	4.25 ± 1.20^{a}
Sour taste	3.20 ± 0.69^{b}	3.63 ± 1.08^{a}	3.56 ± 1.05^{ab}	3.63 ± 1.14^{a}	3.44 ± 1.40^{ab}
Cocoa flavor	3.09 ± 0.70^{b}	3.43 ± 0.91^{a}	3.31 ± 0.92^{ab}	3.28 ± 1.04^{ab}	2.79 ± 1.26^{c}
Whey flavor	3.20 ± 0.66^{a}	2.95 ± 0.81^{b}	2.98 ± 0.97^{ab}	2.86 ± 1.02^{b}	2.78 ± 1.19^{b}
Caramel flavor	2.83 ± 0.71^{a}	2.23 ± 0.81^{b}	2.22 ± 0.89^{b}	2.08 ± 0.93^{b}	1.84 ± 0.95^{c}
Sandiness	3.21 ± 0.62^{c}	3.30 ± 0.77^{bc}	3.60 ± 1.06^{b}	4.15 ± 1.32^{a}	3.23 ± 0.93^{c}
Consistency	3.23 ± 0.73^{a}	2.40 ± 0.78^{b}	2.52 ± 0.82^{b}	2.53 ± 0.99^{b}	2.38 ± 0.80^{b}
Viscosity	3.38 ± 0.77^{a}	2.51 ± 0.81^{b}	2.61 ± 0.75^{b}	2.59 ± 0.99^{b}	2.48 ± 0.82^{b}

[a,b,c] Means in the column followed by different lowercase letters differ from the treatments (Tukey test; $p < 0.05$). [1] BCC = control commercial formulation; BCE = control experimental formulation; BFA = beverage with açaí flour; BFB = beverage with beetroot flour; BFH = beverage with hibiscus flour.

2.3. Sensory Acception and Characterization

All sensory evaluations underwent review and approval by the Ethics and Research Committee of UFBA under protocol CAAE 60414022.7.0000.5531. Written informed consent was obtained from all participants during the food-tasting sessions. Individuals with lactose intolerance or allergies to milk and its derivatives were excluded from participating in this research. This study was divided into two sections of sensory research (Figure S1). In the first section, the acceptability and characterization of the cow and buffalo whey-based cocoa beverage were evaluated through overall acceptability, purchase intention, and JAR (just-about-right) scaling. This was conducted at the School of Veterinary Medicine of the Federal University of Bahia, Brazil, and involved a sample size of 120 untrained participants (84 women and 36 men, respectively), with ages ranging from 18 to 66 years old. In the second study, an assessment of the effect of information was conducted. The analyses were conducted at the Faculty of Pharmacy, Nutrition School, and School of Veterinary Medicine of the Federal University of Bahia, Brazil. The study involved a sample size of 164 untrained participants (114 women and 50 men, respectively), with ages ranging from 18 to 66 years old.

Consumers were randomly recruited based on their interest and willingness to participate in the study. The sensory tests were conducted in individual booths with white lighting, set up in a controlled environment maintained at a temperature between 22 and 24 °C with proper air circulation. The samples, served in 50 mL plastic cups, were chilled to 4 ± 2 °C, and 20 mL of each sample was provided to the assessors. The samples were coded with 3-digit random codes in sequential monadic order following a balanced complete block design. To cleanse the palate between samples, assessors were provided with salt biscuits and filtered water at room temperature (25 °C).

2.3.1. Acceptability and Purchase Intention

In the acceptability test, the assessors were asked to evaluate each sample's appearance, color, odor, flavor, consistency, mouthfeel, and overall impression using a 9-point hedonic scale (from 1 = extremely dislike to 9 = extremely like), using the Table S3 to describe each attribute when needed. Purchase intention was evaluated using a 5-point category scale (1 = certainly would not buy, 5 = certainly would buy) following the methodology of Meilgaard [33].

2.3.2. Just-About-Right (JAR)

The JAR test was conducted to determine the optimal intensity of sensory attributes in the cow and buffalo whey-based cocoa beverage. Consumers evaluated attributes such as aroma (sweet, cocoa, bitter, milk), taste (sweet, bitter, sour), flavor (cocoa, whey, caramel), color (amber, caramel, red), and texture (sandiness, consistency, viscosity, mouthfeel) using a just-about-right scale with five points (1 = not enough, 3 = ideal, 5 = too much), as described by Meilgaard [33].

2.3.3. Check-all-That-Apply (CATA)

Participants received a list of 24 terms in the check-all-that-apply (CATA) format. Each participant was asked to select all the terms that described the sensory characteristics of each treatment. The terms included attributes related to aroma (fruity aroma, cocoa aroma, whey aroma, sweet aroma, milk aroma, bitter aroma), taste and flavor (bitter taste, sour taste, sweet taste, milk flavor, whey flavor, chocolate flavor, fruity flavor), appearance (dark brown color, light brown color, red color, homogeneous appearance, shiny), and texture (sandiness, fat sensation, foam, consistent, viscous, fluid). Ref. [34] also balanced the presentation order of descriptive terms.

2.4. Information Effect on Consumer Perceptions

The consumer perception test included the participation of 164 untrained assessors. The environmental conditions and sample delivery followed the same procedures as in the previous study. Three samples were used: BFA and BFH, selected based on their acceptance in the previous study, and a dummy sample containing a mixture of both, according to [35]. To mitigate the first-sample effect, the dummy sample was served first, while the other samples were served in a balanced complete block design and sequential monadic order. Only the results of BFA and BFH were considered for the study.

The consumers were randomly divided into three groups: The blind group (62 participants) received no information. The second group (62 participants) received the following information: "You will taste a new cocoa beverage with the addition of purple flours with a high content of antioxidants. The purple flours used in this study contain significant levels of phenolic acids, flavonoids, and anthocyanins, exhibiting antihypertensive, hypoglycemic, hypolipidemic, antianemia, anti-inflammatory, and antioxidant effects, in addition to potential effects on body weight control and loss." The third group (62 participants) received the information: "You will taste a new cocoa beverage made with whey, which is the largest by-product of the dairy industry. Whey is a by-product obtained during cheese production (an average of 9 L of whey is produced for each kilogram of cheese). However, in Brazil, only 60% of this whey is reused. A significant amount is still discarded in nature, posing a high polluting potential, which can harm aquatic life and ecosystems".

Acceptance evaluation included overall taste, bitter taste, mouthfeel, and overall impression as attributes, rated on a 9-point hedonic scale (1 = extremely dislike, 9 = extremely like). Purchase intention was evaluated using a 5-point category scale (1 = certainly would not buy, 5 = certainly would buy). Additionally, a CATA questionnaire consisting of 18 terms was used to capture responses related to emotions and feelings. The terms included descriptors such as good for health, tasteless, sad, pacific, environmentally friendly, happy, nutritious beverage, animal welfare, satisfaction, sustainability, animal exploitation, natural beverage, ecological, disappointment, optimism, rejection, energetic, and emotionless.

2.5. Statistical Analysis

The acceptance, purchase intention, and consumer perception results were analyzed via one-way ANOVA and subjected to Tukey's test at $p < 0.05$. Penalty analysis was carried out on JAR data to relate the adequacy of the attributes and overall liking where consumers rated the attributes at "not enough" or "too much". In both CATA analyses, the frequency of each descriptor was calculated through counting the number of consumers who used it to describe each sample and using Cochran's Q test ($p < 0.05$) to identify differences between the sample for each descriptor. Principal component analysis (PCA) was performed to obtain a bidimensional representation of the relationship between samples and descriptors. All analyses were performed using the statistical program XLSTAT version 2013.2.03 (Addinsoft, Paris, France).

3. Results and discussion

3.1. Acceptance Test and Purchase Intention

The results of sensory attribute acceptance for the buffalo whey-based cocoa beverage are illustrated in Figure 1. In terms of acceptance, for a product to be considered accepted, it must have an acceptance greater than or equal to seven; using this logic, only the BCC could be considered as accepted [36]. The BCC treatment, formulated to resemble a commercial product, obtained higher acceptance scores in all attributes due to its familiar characteristics for consumers [37], being rated between "slightly like" and "moderately like" (6–7). On the other hand, when comparing treatments with the same formulation (BCE, BFA, BFB, and BFH), significant differences between samples ($p \leq 0.05$) were detected for all attributes, indicating that the addition of açaí, beetroot, and hibiscus flour reduced the acceptance of cocoa buffalo whey milk-based beverages. However, studies [38] have shown that the use of dark chocolate with high concentrations in the production of beverages reduces their acceptance, mainly due to its bitter taste and astringency on the palate, due its high content of alkaloids, amino acids, peptides, pyrazines, and polyphenols, respectively.

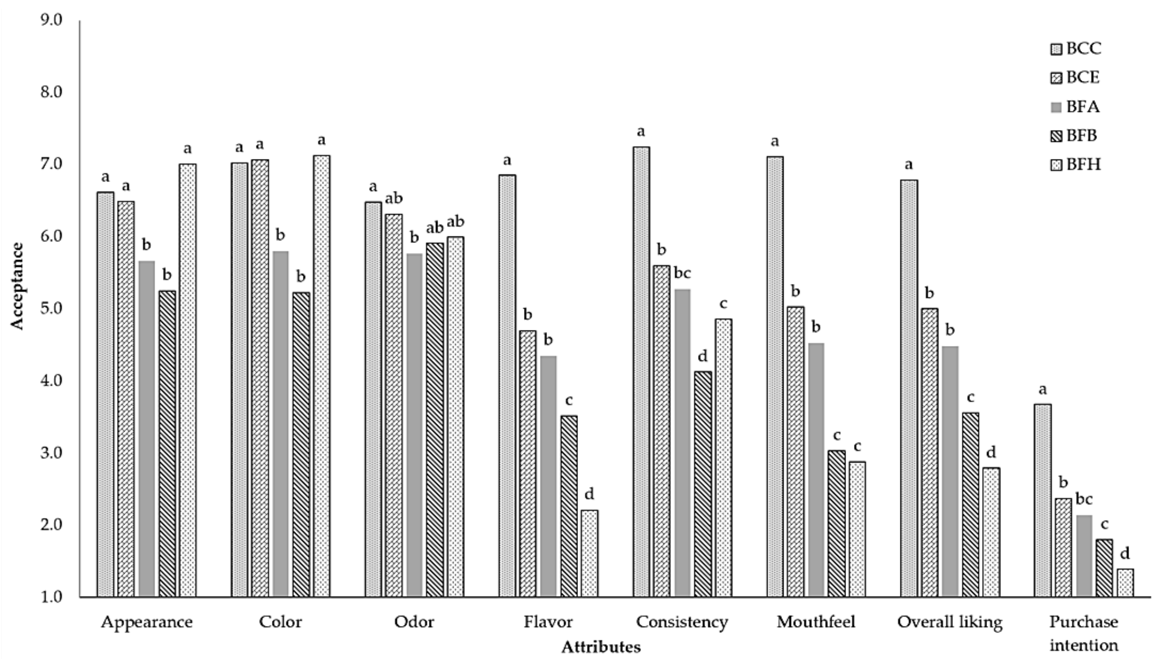

Figure 1. The average of the hedonic values obtained from the acceptance test for buffalo whey-based cocoa beverages. [a,b,c,d] Means in the bar followed by different lowercase letters significantly differ from the treatments (Tukey test; $p < 0.05$). BCC = control commercial formulation; BCE = control experimental formulation; BFA = beverage with açaí flour; BFB = beverage with beetroot flour; BFH = beverage with hibiscus flour. Purchase intention analysis was evaluated on a 5-point category scale.

However, in terms of appearance and color attributes, which are assessed via sight, there was no significant difference ($p \leq 0.05$) between the BCC, BCE, and BFH treatments. This may be associated with the higher acceptance of foods with more intense color [39]. For instance, adding açaí and beetroot flour resulted in lower ($p < 0.05$) scores for appearance and color; this may have influenced the color of the beverages. Beetroot has a high content of betalains, water-soluble compounds, which could have given the beverages a more purple color [40]; in turn, açaí contains high content of anthocyanins [41]. However, when comparing BFA with BCE, the control with the same formulation, there were no significant (p > 0.05) differences in the scores for flavor, consistency, mouthfeel, and overall liking, which were rated between "dislike slightly" and "like slightly" (4–6). In contrast, adding beetroot and hibiscus flour had a pronounced ($p < 0.05$) impact on these attributes.

Here, the influence of the flavor attribute on the acceptance of subsequent attributes or even and the acceptances of the product was observed. Overall, the assessors evaluated the BCC treatment more positively. In contrast, the BFH treatment scored between "dislike very much" and "dislike slightly" (2–4) for the attributes of flavor, consistency, mouthfeel, and overall liking. Notably, the positive evaluation of the BCC treatment contrasted with the less favorable perception of the BFH treatment, emphasizing the intricate relationship between flavor and the overall liking of the beverage [39].

Regarding purchase intention, three groups were observed. The BCC treatment exhibited the highest potential for consumer purchase, with evaluations indicating a likelihood of "might or might not buy" (scores of around three). Conversely, the second group included the BCE and BFA treatments, which garnered responses indicating lower likelihoods, leaning towards "probably would not buy" (scores around two). Notably, the BFH treatment received the least favorable evaluation, with assessors expressing a clear inclination of "definitely would not buy" (scores around one).

3.2. Just-About-Right (JAR) and Penalty Analysis

Information for the JAR test and penalty are described in Tables 1 and 2. For the JAR test, a scale of five was used, with three being the ideal point. All treatments are ideal in amber, brown, and red colors (Table 1). However, the BFB treatment was above ideal in red color, due to its betalain content [41]. The BFA, BFB, and BFH treatments had lower scores for amber, brown, and red colors. In the sweet aroma, all treatments were below ideal, with BFH having the greatest effect, which is also reflected in the result of the acid aroma; BFH had a higher score compared to the other treatments. In a similar study, Iwalokun and Shittu [42] observed reduced acceptance of treatments containing hibiscus extract, which is known for its high content of anthocyanins, ascorbic acid, and antioxidants, contributing to an intense bitter taste [43]. However, as expected, the treatments with 100% cocoa had a higher score in the cocoa aroma and flavor attributes; however, despite having the same formulation, the hibiscus treatment was classified as having a lower score in these attributes. In other ways, the aroma of milk was classified as ideal, due to consumers relating the dairy beverage directly to milk; however, as can be seen in Table S2, the treatments do not contain milk, demonstrating that replacing milk with whey can be a reliable alternative.

Treatments with 100% cocoa were classified as non-ideal in terms of sweet flavor; this outcome can be attributed to the high concentration of cocoa in the formulations, which typically results in a more intense chocolate flavor with pronounced acidity and bitterness, as noted by de Jesus Silva et al. [44]. Again, the BFH treatment had a greater effect on the sweet flavor and sour flavor attributes, being suboptimal and above ideal, respectively. The treatment with the addition of beetroot, BFB, was classified above the right level in terms of sandiness, which may be related to the low solubility of beetroot, leaving the sensation of larger particles. Treatments with added inulin were considered lower than the right level compared to treatments with added xanthan gum. Studies have demonstrated the great capacity of xanthan gum to improve viscosity, gel formation, and beverage consistency [45].

In this sense, as expected, regarding sweet aroma and sweet taste, all treatments received penalties for being perceived as insufficient (Table 2); however, treatments containing 100% cocoa were heavily penalized, which demonstrates the low acceptance of dark chocolate [38]. However, the absence of a sweet flavor had a more pronounced impact on the acceptance of the BFH treatment, as it was penalized by a higher percentage of consumers (91.67%) for lacking sufficient sweetness. Similarly, 80.67% of consumers penalized the same treatment for having an excessively bitter taste. However, the effect was also observed in treatments BCE, BFA, and BFB, which were penalized for having an excessive bitter aroma and bitter taste. The BFA, BFB, and BFH treatments received penalties from over 20% of consumers for the whey flavor attribute, indicating individual taste variability [46]. Similar patterns were observed for the attributes of sour taste and cocoa flavor in the BFH treatment, bitter taste in the BFB treatment, and amber color in the BFA treatment. Additionally, consumers noted excessive sandiness in the BCE, BFA, and BFB treatments. In contrast, treatment BCE was considered to have the ideal consistency (Table 2), making it the only one without penalties for this attribute. Only the BCE and BFA treatments were penalized for not having enough viscosity.

Table 2. Consumer penalty analysis of the just-about-right (JAR) diagnostic attributes, percentage of consumers (%), and mean drop.

Attributes	BCC [1]		BCE		BFA		BFB		BFH	
	NE [2]	TM [3]	NE	TM	NE	TM	NE	TM	NE	TM
Amber color	— [5]	—	—	—	21.67 (0.91) [4]	22.69 (0.69)	31.67 (0.50)	—	—	—
Brown color	20.83 (0.56)	—	—	—	—	42.86 (0.92)	39.17 (1.22)	—	—	29.41 (0.71)
Red color	—	—	—	—	—	21,01 (1.05)	—	70,59 (1.81)	—	—
Sweet aroma	26.67 (1.00)	—	51.67 (1.41)	—	56.67 (2.29)	—	52.50 (1.60)	—	68.33 (1.33)	—
Cocoa aroma	26.67 (1.28)	—	—	35.29 (1.74)	—	35.29 (1.36)	—	32.77 (1.22)	33.33 (1.53)	—
Bitter aroma	—	—	—	22.69 (1.64)	—	29.41 (1.35)	—	36.13 (0.82)	—	61.34 (1.70)
Milk aroma	—	—	38.33 (1.23)	—	45.83 (1.84)	—	45.83 (1.75)	—	—	—
Sweet taste	25.00 (1.02)	—	74.17 (1.60)	—	67.50 (2.20)	—	72.50 (1.98)	—	91.67 (3.31)	—
Bitter taste	—	—	—	32.77 (1.28)	—	36.13 (1.50)	20.00 (0.67)	39.50 (0.68)	—	80.67 (2.61)
Sour taste	—	22.69 (0.81)	—	55.46 (2.06)	—	51.26 (1.68)	—	57.14 (1.70)	24.17 (2.39)	53. 78 (1.53)
Cocoa flavor	—	—	—	41.18 (2.47)	—	38.66 (1.55)	—	36.13 (1.39)	42.50 (1.32)	28.57 (0.78)
Whey flavor	—	20.17 (0.89)	25.00 (1.87)	—	23.33 (2.39)	25.21 (1.25)	32.50 (1.63)	23.53 (1.32)	42.50 (1.49)	27.73 (1.38)
Caramel flavor	25.83 (1.06)	—	56.67 (1.22)	—	57.50 (1.88)	—	64.17 (1.09)	—	76.67 (0.74)	—
Sandiness	—	—	—	31.93 (0.56)	—	60.50 (1.02)	—	79.83 (1.33)	—	—
Consistency	—	—	48.33 (1.05)	—	40.33 (1.27)	—	45.83 (0.62)	—	50.00 (0.68)	—
Viscosity	—	—	46.67 (1.03)	—	38.33 (1.22)	—	—	—	—	—

[1] BCC = control commercial formulation; BCE = control experiment formulation; BFA = beverage with açaí flour; BFB = beverage with beetroot flour; BFH = beverage with hibiscus flour. [2] NE = not enough. [3] TM = too much. [4] The number between the parentheses indicate the mean drop, calculated via subtracting the mean overall JAR acceptance of the group from the mean global acceptance of the group. [5]—indicates that less than 20% of consumers found the sensory attribute from the JAR score to be too little or too much.

3.3. Check-All-That-Apply (CATA)

According to the results of the Q Cochran analysis, there were no significant differences ($p < 0.05$) in 5 terms (fruity aroma and flavor, whey aroma and flavor, and milk aroma) out of the 23 terms used in the CATA question to describe the samples (Table 3). These findings, in line with those of Vidal et al. [47], indicate that consumers could perceive differences in the sensory characteristics of the beverages. The CATA method also helps identify the characteristics that impact overall liking [48].

Table 3. Frequency (%) of each term of the CATA was indicated by consumers for different formulations of buffalo whey-based cocoa beverage.

Attribute	BCC [1]	BCE	BFA	BFB	BFH	*p*-Value
Fruity aroma	6.7 [a]	9.2 [a]	5.8 [a]	13.3 [a]	12.5 [a]	0.116
Cocoa aroma	44.2 [c]	69.2 [a]	65.0 [ab]	52.5 [bc]	44.2 [c]	<0.0001
Whey aroma	15.8 [a]	6.7 [a]	15.0 [a]	14.2 [a]	10.0 [a]	0.053
Sweet aroma	32.5 [a]	11.7 [b]	10.8 [b]	10.8 [b]	5.0 [b]	<0.0001
Milk aroma	11.7 [a]	7.5 [ab]	5.0 [ab]	1.7 [b]	4.2 [ab]	0.012
Bitter aroma	0.8 [c]	12.5 [bc]	20.8 [b]	10.0 [bc]	40.0 [a]	<0.0001
Bitter taste	1.7 [c]	29.2 [b]	35.0 [b]	35.0 [b]	81.7 [a]	<0.0001
Sour taste	19.2 [c]	75.8 [a]	69.2 [ab]	66.7 [ab]	57.5 [b]	<0.0001
Sweet taste	49.2 [a]	5.8 [b]	8.3 [b]	5.8 [b]	0.8 [b]	<0.0001
Milk flavor	40.8 [a]	8.3 [b]	11.7 [b]	5.8 [b]	3.3 [b]	<0.0001
Whey flavor	11.7 [a]	14.2 [a]	19.2 [a]	10.8 [a]	14.2 [a]	0.250
Chocolate flavor	66.7 [a]	40.0 [b]	29.2 [b]	25.8 [bc]	10.8 [c]	<0.0001
Fruity flavor	3.3 [a]	5.8 [a]	7.5 [a]	10.8 [a]	11.7 [a]	0.045
Dark brown color	23.3 [d]	54.2 [bc]	80.8 [a]	39.2 [cd]	70.0 [ab]	<0.0001
Light brown color	50.8 [a]	28.3 [b]	5.0 [c]	6.7 [c]	2.5 [c]	<0.0001
Red color	5.0 [b]	6.7 [b]	15.8 [b]	68.3 [a]	17.5 [b]	<0.0001
Sandiness	16.7 [c]	30.0 [c]	60.0 [b]	79.2 [a]	26.7 [c]	<0.0001
Fat sensation	17.5 [a]	5.8 [c]	13.3 [bc]	10.0 [bc]	5.8 [c]	0.007
Foam	32.5 [a]	9.2 [bc]	17.5 [b]	4.2 [c]	3.3 [c]	<0.0001
Homogeneous appearance	46.7 [ab]	45.8 [ab]	30.0 [b]	30.8 [b]	49.2 [a]	0.001
Shiny	63.3 [a]	61.7 [a]	48.3 [ab]	43.3 [b]	57.5 [ab]	0.001
Consistent	49.2 [a]	2.5 [b]	5.0 [b]	5.8 [b]	3.3 [b]	<0.0001
Viscosity	44.2 [a]	3.3 [b]	5.0 [b]	11.7 [b]	2.5 [b]	<0.0001
Fluid	19.2 [d]	51.7 [a]	38.3 [ab]	20.8 [cd]	35.8 [bc]	<0.0001

[a,b,c,d] Means in the same line followed by different lowercase letters differ from the treatments (Tukey test; $p < 0.05$). [1] BCC = control commercial formulation; BCE = control experiment formulation; BFA = beverage with açaí flour; BFB = beverage with beetroot flour; BFH = beverage with hibiscus flour.

Consequently, terms such as “sour taste” and “dark brown color” were frequently used to describe the treatments containing 100% cocoa, which confirms the results obtained from the penalty analysis (Table 2). In addition, the BCC treatment was predominantly described using terms such as “sweet taste”, “milk flavor”, “chocolate flavor”, “light brown color”, “consistency”, and “viscosity” when compared to the other treatments. These terms can be considered the main characteristics contributing to increased product acceptance. Furthermore, the BFH treatment was mostly associated with the terms "sour aroma" (40.0%) and "sour taste" (81.7%).

Figure 2 depicts a two-dimensional representation of the principal component analysis (PCA) conducted on the CATA data of buffalo whey-based cocoa beverages. The PCA analysis accounted for 84.47% of the variation in the data, with the first and second dimensions explaining 68.24% and 19.23% of the variance, respectively. Among the various treatments, the BCC treatments showed the highest number of associated terms, including "milk aroma", "foam", "light brown color", "milk flavor", "chocolate taste", "sweet aroma", "viscosity", "consistency", and "sweet taste." In contrast, the BCE, BFA, and BFH treatments were primarily linked to terms like "sour taste", "sour aroma", "fluidity", "dark brown color", "cocoa aroma", "bitter taste", "fruity flavor", "homogeneous appearance", and "shininess". Additionally, the BFB treatment was predominantly associated with "sandiness" and "red color".

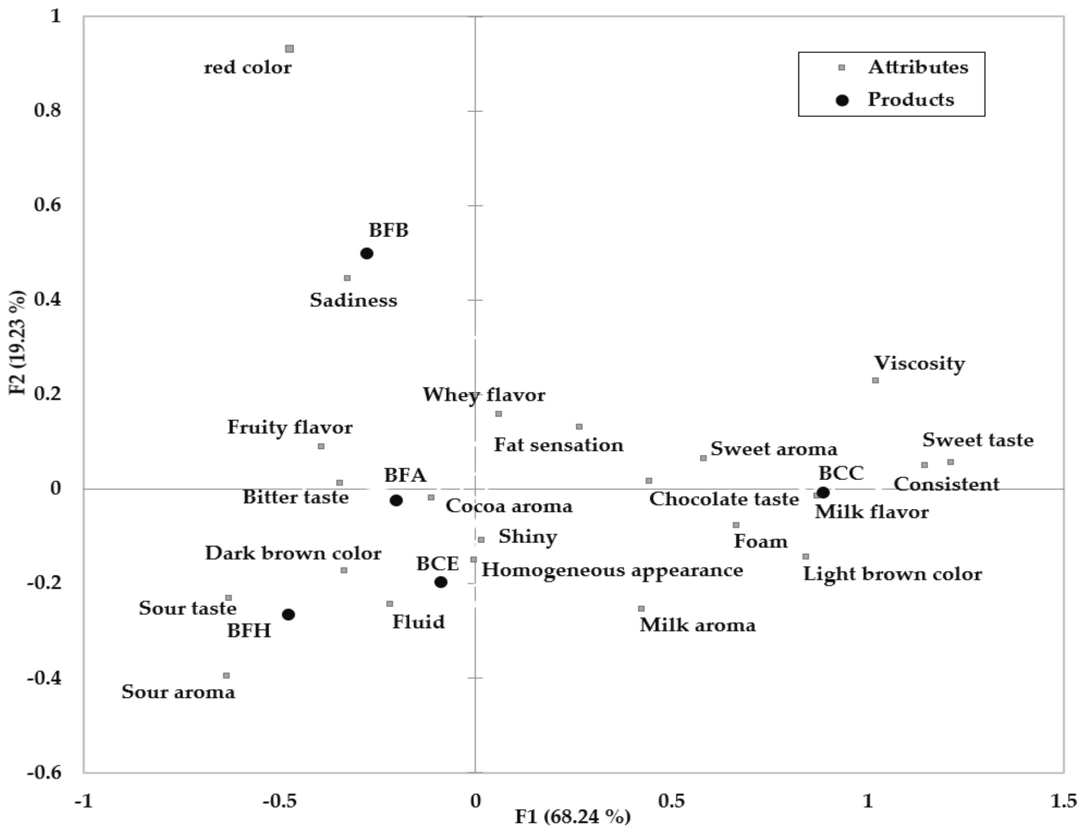

Figure 2. Bidimensional representation of principal component analysis (PCA) of buffalo whey-based cocoa beverage. BCC = control commercial formulation; BCE = control experiment formulation; BFA = beverage with açaí flour; BFB = beverage with beetroot flour; BFH = beverage with hibiscus flour.

These findings underscore the critical significance of taking into account sensory attributes and consumer preferences during the development of buffalo whey-based cocoa beverages. A comprehensive understanding of the individual ingredients' influence and their sensory characteristics can be instrumental in fine-tuning formulations, thereby elevating their acceptance and overall popularity among consumers. Furthermore, it is essential to emphasize the importance of incorporating information related to health and sustainability into the product development process. This strategic approach not only aligns products with consumer expectations and desires but also contributes to their market success. Simultaneously, it addresses growing concerns surrounding health and sustainability, ultimately fostering a more responsible and environmentally conscious industry. In conclusion, the integration of sensory attributes, consumer preferences, and a commitment to health and sustainability is pivotal in the successful creation of cocoa buffalo milk whey-based beverages. This holistic approach not only ensures product acceptance but also positions the industry as a responsible and forward-thinking player in the market.

3.4. Consumer Perception

The impact of health and sustainability information on the flavor, sour taste, mouthfeel, overall liking, and purchase intention of the BFA and BFH treatments were not found to be significant ($p < 0.05$). These results suggest that the information provided to consumers did not significantly influence their acceptance of the final product, as indicated in Table 4. This pattern could be attributed to the overall low acceptance of beverages, as previous studies have highlighted the powerful effect of flavor on the acceptance of food products, even when they possess beneficial health characteristics [48].

Table 4. The average of the hedonic values obtained from the acceptance test for BFA and BFH treatments by the blind and informed groups.

Treatment	Information	Attribute				
		Flavor	Sour Taste	Mouth Feeling	Overall Linking	Purchase Intention
BFA [1]	Blind [2]	6.67 ± 1.88 [a]	6.78 ± 1.67 [a]	6.96 ± 1.49 [a]	6.89 ± 1.67 [a]	3.50 ± 1.09 [a]
	Health [3]	6.31 ± 1.93 [a]	6.59 ± 1.76 [a]	6.56 ± 1.84 [a]	6.56 ± 1.73 [a]	3.48 ± 1.08 [a]
	Sustainability [4]	6.17 ± 2.09 [a]	6.46 ± 2.03 [a]	6.35 ± 2.04 [a]	6.22 ± 2.06 [a]	3.24 ± 1.10 [a]
	Blind	2.98 ± 2.00 [a]	3.33 ± 1.95 [a]	3.56 ± 1.85 [a]	3.37 ± 1.85 [a]	1.59 ± 0.86 [a]
BFH	Health	3.20 ± 1.94 [a]	3.19 ± 1.87	3.52 ± 2.13 [a]	3.09 ± 1.85 [a]	1.61 ± 0.88 [a]
	Sustainability	3.15 ± 2.17 [a]	3.41 ± 2.33 [a]	3.20 ± 2.19 [a]	3.31 ± 2.22 [a]	1.76 ± 1.04 [a]

[a] Means in the same column followed by different lowercase letters differ from the kinds of information (Tukey test; $p < 0.05$). [1] BFA = beverage with açaí flour; BFH = beverage with hibiscus flour. [2] Blind = participants received the samples without information. [3] Health = participants received the samples with health information. [4] Sustainability = participants received the samples with sustainability information.

On the other hand, the Q Cochran analysis unveiled a noteworthy distinction ($p < 0.05$) in consumers' emotional responses based on the type of information they received for both treatments. Those who were provided with health-related information were notably more inclined ($p < 0.05$) to employ expressions such as "beneficial for health" and "nutrient-rich beverage" when describing their emotional experience during the trial, as depicted in Table 5. In contrast, sustainability information prompted an increased usage of terms like "sustainable", "supporting nature", and "ecological" for both treatments. Ultimately, these findings underscore the distinct impact of health and sustainability information on consumers' emotional reactions. Health information engendered positive associations with nutritional advantages, while sustainability information sparked an awareness of environmental conscientiousness. Recognizing the influence of such information on consumer emotions can offer invaluable insights for product positioning and communication strategies.

Table 5. Frequency (%) of each term of the CATA was indicated by consumers for different information in each buffalo whey-based cocoa beverage.

Emotion	BFA [1]			p-Value	BFH			p-Value
	Blind [2]	Health [3]	Sustainability [4]		Blind	Health	Sustainability	
Good for health	37.04 [b]	70.37 [a]	31.48 [b]	<0.0001	11.11 [b]	44.44 [a]	18.52 [b]	0.000
Nutritious beverage	46.30 [a]	64.81 [a]	42.59 [a]	0.045	12.96 [b]	38.89 [a]	14.81 [b]	0.002
Energetic	29.63 [a]	18.52 [a]	24.07 [a]	0.394	9.26 [a]	11.11 [a]	11.11 [a]	0.926
Pacific	16.67 [a]	25.93 [a]	9.26 [a]	0.079	3.70 [a]	3.70 [a]	3.70 [a]	1.000
Happy	24.07 [a]	31.48 [a]	31.48 [a]	0.633	5.56 [a]	1.85 [a]	3.70 [a]	0.607
Optimistic	33.33 [a]	37.04 [a]	27.78 [a]	0.607	5.56 [a]	7.41 [a]	7.41 [a]	0.913
Satisfied	57.41 [a]	53.70 [a]	51.85 [a]	0.850	11.11 [a]	14.81 [a]	3.70 [a]	0.155
Natural beverage	29.63 [a]	46.30 [a]	37.04 [a]	0.166	11.11 [a]	24.07 [a]	16.67 [a]	0.186
Sustainable	16.67 [b]	20.37 [b]	55.56 [a]	<0.0001	12.96 [b]	11.11 [b]	38.89 [a]	0.000
Ecological	16.67 [b]	11.11 [b]	37.04 [a]	0.002	5.56 [b]	5.56 [b]	29.63 [a]	0.000
Help nature	9.26 [b]	16.67 [ab]	33.33 [a]	0.004	3.70 [b]	3.70 [b]	22.22 [a]	0.001
Animal welfare	11.11 [a]	7.41 [a]	18.52 [a]	0.193	1.85 [a]	3.70 [a]	11.11 [a]	0.050
Animal exploitation	1.85 [a]	0.00 [a]	3.70 [a]	0.368	1.85 [a]	0.00 [a]	1.85 [a]	0.607
Disappointed	7.41 [a]	3.70 [a]	3.70 [a]	0.607	40.74 [a]	37.04 [a]	35.19 [a]	0.823
Rejection	5.56 [a]	1.85 [a]	3.70 [a]	0.607	61.11 [a]	38.89 [a]	50.00 [a]	0.072
Sad	1.85 [a]	0.00 [a]	3.70 [a]	0.368	20.37 [a]	11.11 [a]	22.22 [a]	0.229
Unlike	7.41 [a]	1.85 [a]	5.56 [a]	0.417	55.56 [a]	48.15 [a]	42.59 [a]	0.337
Emotionless	11.11 [a]	5.56 [a]	5.56 [a]	0.407	27.78 [a]	12.96 [a]	12.96 [a]	0.085

[a,b] Means in the same line followed by different lowercase letters differ from the kinds of information (Tukey test; $p < 0.05$). [1] BFA = beverage with açaí flour; BFH = beverage with hibiscus flour. [2] Blind = participants received the samples without information. [3] Health = participants received the samples with health information. [4] Sustainability = participants received the samples with sustainability information.

4. Conclusions

Higher acceptance levels were observed when cocoa powder was used in lower proportions and combined with cane sugar. This fact highlights the importance of finding the right balance of ingredients to achieve optimal flavor profiles that align with consumer preferences. However, incorporating açaí, beetroot, and hibiscus flour into buffalo whey-based cocoa beverages resulted in a decline in overall acceptance, primarily due to the strong bitter taste associated with hibiscus flour. Furthermore, beverages containing 100% cocoa faced penalties due to inadequate aroma and insufficient sweetness. Remarkably, the type of information provided to consumers significantly impacted their emotional responses. These findings emphasize the role of information in shaping consumer perceptions and highlight the potential of leveraging audiovisual aids, such as videos, to enhance consumer understanding and engagement. Therefore, through optimizing ingredient proportions, addressing flavor concerns, and effectively conveying information, the dairy industry can create products that resonate with consumers, improving acceptance and market success. In this context, further studies can be provided to maximize consumers' acceptance through optimizing formulas with more edulcorates or saccharose and through adding a proportion of whole milk.

Supplementary Materials: The following supporting information can be downloaded at: www.mdpi.com/xxx/s1, Table S1: Cow and buffalo whey proximal composition (means ± SD). Table S2: Formulation of cow and buffalo whey-based cocoa beverage. Table S3: Attributes evaluated with definition. Figure S1: Study design illustrating the stages involved in the experiment. BCC = control commercial formulation; BCE = control experimental formulation; BFA = dessert with açaí flour; BFB = dessert with beetroot flour; BFH = dessert with hibiscus flour.

Author Contributions: M.P.d.C. and M.J.G.S. conceived the initial idea; M.P.d.C., D.M.O., and M.E.d.O.M. supervised the study; M.J.G.S. and M.P.d.C. developed the methodology and review and wrote the original draft; M.J.G.S., M.P.d.C., A.C.d.O.A., B.S.d.S.R., and U.M.P. carried out the sensory experiments; M.J.G.S., I.L.d.S.R., A.C.d.O.A., B.S.d.S.R., U.M.P., M.P.d.C., D.M.O., and M.E.d.O.M. collected, analyzed, formatted, and interpreted the data and edited the manuscript. All authors have read and agreed to the published version of the manuscript.

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Data Availability Statement:

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Supplementary Materials:

Table S1. Cow and buffalo whey proximal composition (means ± SD).

Whey type	Proximal composition					
	Fat	Protein	Lactose	Minerals	Total solids	Solids not fat
Cow whey	0.59 ± 0.01	2.69 ± 0.01	4.02 ± 0.01	0.59 ± 0.00	7.89 ± 0.02	7.31 ± 0.02
Buffalo whey	0.35 ± 0.01	2.86 ± 0.01	4.27 ± 0.01	0.63 ± 0.00	8.10 ± 0.01	7.75 ± 0.02

Table S2. Formulation of cow and buffalo whey-based cocoa beverage.

Ingredient	BCC[1]	BCE	BFA	BFB	BFH
Cow whey	88.75	---	---	---	---
Buffalo whey	---	86.5	84.0	84.0	84.0
Xanthan gum	0.25	---	---	---	---
Inulin	---	2.5	2.5	2.5	2.5
Sugar	3.5	---	---	---	---
Xylitol	---	3.5	3.5	3.5	3.5
Cocoa 100 %	7.5	---	---	---	---
Cocoa 50 %	---	7.5	7.5	7.5	7.5
Açaí flour	---	---	2.5	---	---
Beetroot flour	---	---	---	2.5	---
Hibiscus flour	---	---	---	---	2.5

[1] BCC = control commercial formulation; BCE = control experimental formulation; BFA = dessert with açai flour; BFB = dessert with beetroot flour; BFH = dessert with hibiscus flour.

Table S3. Attributes evaluated with definition.

Attributes	Definitions
Appearance	Physical characteristics perceptible with the sense of vision such as color intensity, luminosity, and texture
Color	Result of physical and physiological characteristics of chemical compounds
Odor	Volatile particles are detected in the nasal passage and are perceived by the olfactory system
Flavor	The sensation is obtained by the perception of the olfactory and oral systems.
Consistency	Characteristic of a liquid having the property of resistance to flow
Mouthfeel	Physical characteristics perceptible in the mouth by the consumer such as texture, viscosity, and consistency
Overall liking	The result of the set of perception or acceptance of all attributes
Purchase intention	The probability that the consumer will buy the tested product, is influenced by the rest of the attributes

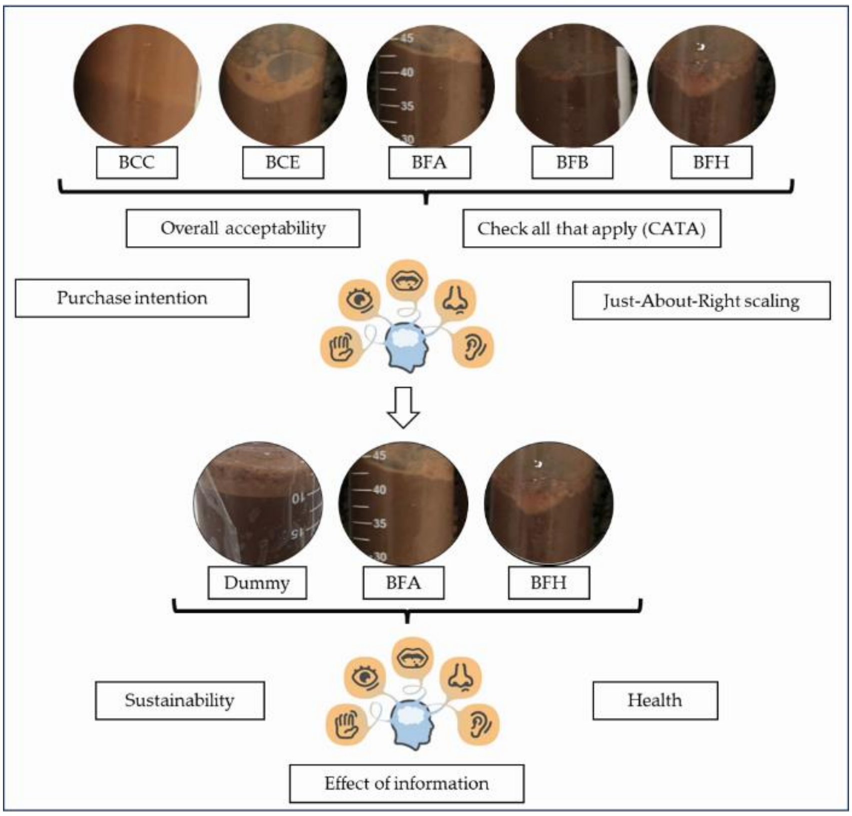

Figure S1. Study design illustrating the stages involved in the experiment. BCC = control commercial formulation; BCE = control experimental formulation; BFA = dessert with açai flour; BFB = dessert with beetroot flour; BFH = dessert with hibiscus flour.

7 CAPÍTULO 03:

Impact of plant-based flour addition on the quality and shelf life of whey-based cocoa beverages

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Impact of plant-based flour addition on the quality and shelf life of whey-based cocoa beverages

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ABSTRACT

Whey is a byproduct of cheese production, contains a high lactose, proteins, minerals, and a low-fat content. Therefore, it is considered a dairy residue with high biological value due to its high content of bioactive compounds. This study aimed to develop 10 formulations of whey-based cocoa beverages by varying the ratios of açai, beetroot and hibiscus flours (0.5, 1.5, and 2.5 % w/v). The formulation underwent proximal composition (d 1) and pH, syneresis, water-holding capacity, instrumental color and microbiological analyzes (0, 5, 10, 15, and 20 d). Incorporating açaí, beetroot and hibiscus flour significantly decreased pH and syneresis. Regarding color parameters (L*, a*, b* and C*) and water retention capacity significantly increased on d 1 of storage. During the 20 d of cold storage, treatments added with beetroot flour had significantly decreased pH and inhibited bacterial growth. All samples presented a trend for increasing syneresis at the end of storage, including for control treatment. A whey-based cocoa beverage with good quality and nutritional characteristics was produced, particularly for the use of whey as the main raw material and easy-to-execute processes. In contrast, the potential of using açaí, beetroot and hibiscus flours to modify the physic-chemical, microbiological and technological properties of whey-based cocoa beverages are highlight in our results.

Keywords: chocolate milk, characterization, residue, fiber.

INTRODUCTION

Cocoa (*Theobroma cacao L.*) is recognized worldwide due to being the main ingredient used in the production of chocolate (Barisic et al., 2023). In the dairy beverage industry, cocoa is generally used in powder form, although processes such as alkalization can be added to produce beverages (Juvinal et al., 2023). Favorized milk chocolate are the most consumed, mainly due to their pleasant taste, odor and for their potential health benefits (Muhammad et al., 2022), and can beverage contain cocoa powder, sugar, milk, and whey (Lucia et al., 2015; Indiarto et al., 2024).

The consumption of chocolate beverages, even though preferred by children and adults, has decreased over time (Zhu et al., 2020). Factors such as the aggregate of sugar and effect of that to consumer health are responsible for this decrease (Keefer et al., 2022). High consumption of sugary foods has been linked to diabetes, obesity, and cardiovascular diseases (Mahato et al., 2020; Darand et al., 2021). Sweeteners such as stevia (Rad et al., 2014; Mahato et al., 2022), monk fruit extract (Mahato et al., 2021), and xylitol (Salgado et al., 2023) have been used to reduced sugar concentration in chocolate milk beverages. Although, preference for sugary foods is correlated to regional, social and age factors (Mahato et al., 2020). Moreover, adding plant-based flours impacted the sensory attributes of the cocoa beverages, such as appearance, aroma, taste, and texture. Beetroot flour added a more purple color to the beverages, and hibiscus flour contributed to a stronger bitter taste. The type of flour and its specific characteristics play a crucial role in the overall success of the product (Salgado et al., 2023).

On the other hand, due to their high content of bioactive compounds such as vitamins and minerals, fruits have been the focus of diverse studies. Increase syneresis, viscosity, and higher water retention are technological properties observed in beverages added with flour of cupuassu (Gutiérrez-Álzate et al., 2023), carrot (Vénica et al., 2020), apple (Popescu et al., 2022), among others. In this sense, fruit flours are characterized by their high fiber content, which several health benefits such as weight loss and eases control blood glucose and blood pressure (Bankole et al., 2023).

In Brazil, legislation allows the use of whey in the formulation of dairy beverages, it can be used as powder, concentrate or liquid (Brazil 2005). Whey is the mayor residue of cheese manufacturing, generating approximately 9 liters of whey for each kilo of cheese produced (Silva et al., 2017). For 2023, a production of 34 billons liters of milk is estimated, which leaves Brazil as the third largest milk producer in the world (MAPA, 2024). However, due to the high cost of the equipment, the use of the whey is unfeasible, so it is discarded, generating the largest waste in the dairy factories (Lavelli and Beccalli, 2022; Sar et al., 2022) mostly by small and mid-size factories than corresponding more than to 27 % of Gross Domestic Product (Maia Santos et al., 2017; Arenhardt and Simonetto, 2023). In this sense, it is important to encourage the development of a process that is easy to execute and a low-cost production.

In this context, the hypothesis was formulated that whether the concentration of açaí, beetroot or hibiscus flour added would influence the technological properties, physicochemical and microbiological characteristics of whey-based cocoa beverages. This research aimed to study the effect of flour addition on the physico-chemical, microbiological, and sensory properties of whey-based cocoa beverages over its shelf life.

MATERIALS AND METHODS

Materials

The whey was obtained from the production of Coalho cheese produced at Laboratory of Milk and Dairy Products Inspection and Technology (LaITLácteos). The whey obtained was underwent a filtration process by fabric tissue with micropores that prevented the passage of large curd particles and was subsequently pasteurized at 65 °C for 30 min and submitted to proximal composition analyzes (Table 2). The whey was then carefully refrigerated at 4 ± 2 °C until the beverage production phase. Açaí and beetroot flour (Viva Nutureza Ind. de produtos naturais Ltda, Viva Nutureza®, Bahia, Brazil), xanthan gum (Sabor Leve, Leve Croc®, Parana, Brazil), xylitol (Natural Vitta comercio de variedades Ltda, Natural Vitta®, Bahia, Brazil), and cocoa powder (50 %) (Nestlé Nordeste alimentos e bebidas Ltda, Bahia, Brazil) were purchased from a local natural product store in Salvador, Bahia, Brazil. Additionally, hibiscus flour (Della Terra Comercio E Distribuidora De Produtos Naturais E Suplementos Ltda, Della Terra®, São Paulo, Brazil) and caseinate (Growth Suplementos, Growth Suplementos - Produtos Alimenticios Ltda, Santa Catarina, Brazil) were acquired from trusted online stores.

Beverage production

The beverages were produced as described by Salgado et al. (2023). In all treatments, xylitol (3.5% w/v), cocoa powder 50 % (7.5% w/v), caseinate (2.5% w/v), xanthan gum (0.25% w/v) and açai, beetroot and hibiscus flours at different concentrations were added to the whey-based beverages (Table 1). The whey was heated until it reaches a temperature of 35 ºC and added to the ration to complete 100%. The resulting blends were formulated following good manufacturing practices and homogenized using a food processor (Philips Walita® RI7630, 600 W, Philips Do Brasil Ltda, São Paulo, Brazil). Subsequently, whey-based beverages were packaged in sterile glass bottles (1000 mL) and refrigerated at 4 ± 2 °C during 20 d of storage (Figure 1). The beverages were subjected to microbiological analysis according to Brasil (2005) to ensure the hygiene of the final product.

pH analyzes

The measurement of the pH of whey and whey-based cocoa beverage were carried out using a precision pH meter Kasvi® electric (K39-2014B) at 20 ºC during storage time (0, 5, 10, 15 and 20 d) (Dos Santos Rosario et al., 2024).

Microbiological analyses

The treatments were analyzed for total and thermotolerant coliforms and psychotrophic bacteria on d 0, and for aerobic mesophiles, molds, and yeasts during storage time (0, 5, 10, 15 and 20 d). For that, the treatments (25 g) were suspended in 225 mL of 0.1% peptone water (Merck, Darmstadt, Germany), submitted to adequate serial dilutions, and inoculated in Petri dishes with selective media for each group of microorganisms. Total and thermotolerant coliforms were estimated through the Most Probable Number (MPN) technique using Lauryl Sulfate Tryptose (LST) broth (Neogen, Lansing, MI, USA), and results were expressed as MPN mL^{-1}. Molds and yeasts were enumerated on Dichloran Rose Bengal Chloramphenicol (DRBC) agar after incubation under aerobiosis at 28°C for 5–7 d. Aerobic mesophiles were enumerated on Plate Count Agar (PCA) after incubation at 37 °C for 24–48 hours. Tryptic Soy Agar (TSA) were used to enumerated psychrotrophs bacterial after incubation at 4 ± 2 °C for 7–10 d. Psychrotrophs, molds and yeasts, aerobic mesophiles, were enumerated using an electronic counter (Flash & Go, IUL instruments, Barcelona, Spain) and expressed as log colony-forming units (CFU) per mL^{-1}. In addition, all microbiological analyses followed American Public Health Association guidelines (APHA, 2005).

Instrumental color analyses

The color parameters of whey-based beverages samples consisting of L* (brightness, 0 = black, 100 = white), a* (+ red, − green), b* (+ yellow, − blue), C =chroma (color intensity) and h (hue angle), were measured during the refrigerated storage (0, 5, 10, 15 and 20 d) using a Minolta Chroma Meter CR-400 (Minolta Camera Co. Ltd, Osaka, Japan). In addition, ΔE (total color difference with control) was calculated using the formula (3) (Haggard et al., 2018):

$$\Delta E = \sqrt{(L_n^* - L_1^*)^2 + (a_n^* - a_1^*)^2 + (b_n^* - b_1^*)^2} \quad (1)$$

Syneresis and Water-Holding Capacity

For measured the syneresis and water-holding capacity whey-based beverages samples were using the methodology described by Gutiérrez-Álzate et al. (2023) with some modifications. 10 g cocoa whey-based beverages were centrifugated at 3300 rmp for 15 min at 4 ºC to separate the supernatant and the precipitated. Syneresis was defined as the ratio of whey weight (supernatant generated) in relation to the original weight of sample. WHC was designated as the ratio of dehydrated gel (precipitate) relative to the total weight of the sample, and were calculated using the following equations:

$$Syneresis\ (\%) = \frac{Weight\ of\ whey\ (g)}{Weight\ of\ samples\ (g)} \times 100 \ldots (2)$$

$$WHC\ (\%) = \frac{Weight\ of\ precipitated\ (g)}{Weight\ of\ samples\ (g)} \times 100 \ldots (3)$$

Statistical analyses

Mean values and standard deviations were calculated. The comparison of multiple samples was performed using two-way ANOVA for pH, microbiological, instrumental color (*L**, *a**, *b** *C**, h and ΔE), and syneresis, water-holding capacity results. Significant differences were compared using the Tukey test at the $P < 0.05$ level. All analyses were performed using GraphPad Prism 8 software (San Diego, CA, USA).

RESULTS AND DISCUSSION

pH values of whey-based cocoa beverage

The pH results of the whey-based cocoa beverages were significantly influenced by the addition of açaí, beetroot, and hibiscus flours over the 20-day storage period at 4 ºC (Figure 2). The control beverage maintained a higher pH compared to all treatments with added flours, which showed a significant decrease in pH ($P < 0.05$). This decrease was most pronounced in the beverages containing hibiscus flour, likely due to the high ascorbic acid content found in hibiscus (Salem et al., 2022), which contributes to increased acidity. The beverages with beetroot flour also showed a significant pH decrease over time, attributed to the degradation of betalains into acidic compounds (Kujala et al., 2000; Abdo et al., 2022), which lower the pH of the beverage. Additionally, previous studies have demonstrated that the acidic nature of these flours can influence the overall pH stability of similar beverage formulations (Coutinho et al., 2019). Additionally, the açaí flour treatment, while causing a moderate pH reduction, contributed to maintaining the antioxidant capacity of the beverage due to the presence of polyphenolic compounds (Pacheco-Palencia et al., 2007). These findings underscore the significant role of plant-based flours in altering the physicochemical properties of whey-based cocoa beverages. Storage time significantly ($P < 0.05$) affected the pH values of whey-based cocoa beverages with added beetroot flour (BBFL, BBFM and BBFH). A notable decrease in pH was observed between day 0 (6.50, 6.46, and 6.33) and day 20 (4.40, 4.47, and 4.38), representing a pH reduction of 31%, 31%, and 32%, respectively, for concentrations of 0.5%, 1.5%, and 2.5% beetroot flour. This drop in pH is attributed to the degradation of betalains into betalamic and isobetalamic acids, which are yellowish in color (Abdo et al., 2022; 2023).

In their study Abdo et al. (2022) report the same behavior in beverages with a high protein content with the addition of beetroot peel water extract at different concentrations (1, 2.5, and 5%). Furthermore, Soutelino et al. (2020) reported that the addition of beet extracts in yogurt decreased pH after 10 d of cold storage, however, they attributed this drop in pH to the activity of lactic acid bacteria used in milk fermentation. The parameter pH is a quality attribute in most of the processed food products, thus, any drastic change can lead to an undesirable impact on flavor, texture, and shelf life of the product (Alizadeh-Sani et al., 2020).

As for the storage period, there was no significant difference in the pH value ($p < 0.05$) between the control treatment and treatments with different concentrations of açaí flour, BAFL, BAFM and BAFH. As reported by Baygut et al. (2023) the addition of açaí pulp did not have significant effects on the pH of fermented beverages, açaí can be considered as a fruit with low acidity, due to its pH that can vary between 4.87 and 5.82 depending on the part of the fruit that was used (Alves et al., 2021).

Microbiological analyses

In all treatments no total or thermotolerant coliforms and psychotropics were detected and were according to prevailing Brazilian legislation governing of dairy beverage, this indicates that there was no evidence of improper pasteurization (Brasil, 2005). According to results, count of molds and yeasts on d 1 of storage, the highest values were found in the BBFM, BHFL, BHFM and BHFH samples, (between 1.24 ± 0.00 and 1.69 ± 0.50), while the samples C_B, BAFL, BAFH, BBFL and BBFH show counts ≤ 1 log CFU/mL. Only the treatment BAFL yeast and mold were not detected on the initial d.

Aerobic mesophiles counts were performed at 5-d intervals during the 20-d storage period (0, 5, 10, 15, and 20 d), growth is illustrated as log CFU/mL counts in Figure 3. Initial counts of mesophilic in all samples of whey-based cocoa beverages were lowest than 5 log CFU/mL, were according to prevailing Brazilian legislation governing of dairy beverage. The addition of some flour affected the growth of aerobic mesophiles bacteria ($P < 0.05$). After fifth d of storage, beverage with beetroot flour addition were not detected mesophiles counts. The decrease in growth of aerobic mesophiles during storage was attributed to phytochemicals identified in beetroot extract decreased of ATP (adenosine 5′-triphosphate) levels and induce of bacterial apoptosis-like death (Gong et al., 2022; Gong et al., 2023). Furthermore, the pH drop over the storage period observed in beverage added with beetroot flour could decrease the counts of bacteria over time. Aerobic mesophiles count in beverage with hibiscus flour addition remained constant ($P < 0.05$) until the end of storage. On the other hand, control beverage and with acai flour addition counts remained stable during the first 10 d and increased after 20 d ($P < 0.05$).

Instrumental color analyses

The color parameters of L* (lightness-darkness), a*(redness-greenness), b*(yellowness-blueness), chroma (C*), hue angle (h*) and ΔE during the storage time of whey-based cocoa beverages are described in table 2. The addition of flour increased ($P < 0.05$) the value of the L* parameter. In their study Della Lucia et al. (2015) described L* values between 30.58 to 50.33 in chocolate beverages sold in Brazil. Sumonsiri et al. (2018) reported L* values between 35.86 to 43.44 in chocolate beverages produced with milk and added microcrystalline cellulose. Darker values were found in all treatments in the present study due to type of cocoa used, cocoa, 50 %, while control samples were significantly ($P < 0.05$) darker. Furthermore, a dark brown color is directly related to greater acceptance of chocolate milk beverages (Salgado et al., 2023; Mahato et al., 2022). As for the storage period, all treatments significantly increased ($P < 0.05$) the L* value. For L* values, all treatments showed oscillatory ($P < 0.05$) throughout 20 d of cold storage. However, the biggest change occurred in the control treatment, where the L* value increased from 15.41 to 24.52 to the end the cold storage and BAFL and BHFL treatments had the highest L* values compared to the rest of the treatments.

In relation to the initial values of a*, which measures the degree of greenness (values from -80 to 0) and redness (values from 0 to 100). As expected, added of beetroot flour increase ($P < 0.05$) a* values, due to the high content of betalains found in beetroot (Santos Rosario et al., 2024). According to Salgado et al. (2023) observed a greater penalty for too much red color in buffalo whey-based cocoa beverages with the addition of beetroot flour and açaí. Control samples had significantly ($P < 0.05$) lower a* than treatment with added flour. As reported previously, chocolate milk beverages have low a* values (Mahato et al., 2022). No significant difference ($P < 0.05$) was observed in the treatments with hibiscus flour and açaí, due to the high content of anthocyanins found in hibiscus and acai (De Jesus et al., 2018; Castro et al., 2021). The a* values in all samples of whey-based cocoa beverages increased ($P < 0.05$) during the 20 d of storage, indicating an increase in the redness of the beverages. A similar pattern was found for reduced-sugar chocolate-flavored milk as reported by Mahato et al. (2022). By contrast, there was no difference between the treatments with the addition of açaí flour (BAFL, BAFM and BAFH), and hibiscus (BHFL, BHFM and BHFH), on 1st d, while on d 5 th, the treatments with the addition of açaí flour had values of a* up to 3.08 times lower than the values on d 1st.

In other cases, the b* values were did not affected ($P < 0.05$) by the addition of flour on the initial d. The b* values increased over time in all treatments, although, at the end of storage, only the treatment BHFM had no significant difference in b* value ($P < 0.05$) compared d 1 to d 20. Physicochemical factors such as pH and sedimentation can influence a* and b* values (Aleman et al., 2023; Castro et al., 2021; Azami et al., 2018). The b* values, with all measurements above zero, confirm that the yellow coloration is dominating over the blue in all samples.

The chroma parameter (C*). BHFM, BHFH and control treatment had significantly ($P < 0.05$) lower C* values than control samples. In contrast, Samples with beetroot flour at the first day had ($P < 0.05$) higher C* values, showing more saturation compared to the other treatments. As observed in the b* parameter, the C* values, throughout storage, increased in all treatments, except for the BHFL treatment, there was no significant difference in the C* value ($P < 0.05$) compared d 1 to d 20.

The hue angle (h*) represents an angular location in a color table relative to the origin such as 0º (red-purple), 90º (yellow), 180º (blue-green), and 270º (blue) to specify color (Zulueta et al., 2007). Flour addition reduces ($P < 0.05$) the h* value. Control treatment had increasing ($P < 0.05$) hº angle value over the time of storage. Furthermore, whereas h* values decreased with the increasing amount of flour ($P < 0.05$), presenting a red-purple color perception. As expected, treatments with added beetroot flour increase ($P < 0.05$) h* values, which is related to its high betalain content, leaving a perceived red color in beverage (Santos Rosario et al., 2024). The day effect was significant ($P < 0.05$), and h* values of all whey-based cocoa beverages samples increased with the increased storage time, except for the BHFL treatment which had the opposite behavior.

Furthermore, the ΔE* value is used to indicate the color difference between the initial treatments (d 1), ΔE* value < 3 indicates that the color difference is imperceptible to the human eye, ΔE* value > 3 indicates that this Differences can be observed by the human eye, and ΔE* values > 6 demonstrate that the samples are in different groups of colors (Lucas et al., 2018; Fernández-López et al., 2018). On d 5th of storage, all treatments had ($P < 0.05$) ΔE* values above 3, except for the BBFM treatment, 2.33. In contrast, treatments BAFL, BAFH and BBFL, had ($P < 0.05$) ΔE* values higher than 6, indicating that the change of color was visible to an untrained person. As for the storage period, the remaining d of storage (10, 15, and 20), ΔE values increased ($P < 0.05$) in all samples. The control treatments, BAFL and BHFL had ($P < 0.05$) greatest color difference on d 15 of storage, and this remained until the end of storage, in contrast, the treatments BAFM, BAFH, BBFL, BBFM, BHFM and BHFH, had ($P < 0.05$) higher ΔE* value on the 15th.

Syneresis and Water-Holding Capacity (WHC)

The mount of syneresis and water retention capacity (WHC) of whey-based cocoa beverages are presented in table 3. The percentages of açaí, beetroot and hibiscus flour correlated inversely with the syneresis values, that is, the higher the percentage of flour significantly ($P < 0.05$) decreased syneresis values, where BAFH, BBFH and BHFH (2.5% flour) presented the lowest value. Demonstrating the high technological potential in adding plant-based flours in the development of beverages, syneresis is an important index when evaluating beverage quality (Gutiérrez-Álzate et al., 2023). However, at the beginning of storage, treatments with the addition of beetroot flour showed the lowest ($P < 0.05$) syneresis rates, compared to the treatments with the addition of açaí and hibiscus. Beetroot flour has been characterized by its high WHC, fiber and hydrophilic compounds content (Kohajdová et al., 2018).

Furthermore, higher effect on syneresis reduction ($P < 0.05$) by the addition of beetroot flour was observed on d 5^{th}. Furthermore, during storage, the control sample did not show ($P < 0.05$) any alterations. the difference between treatments that had fluctuating syneresis values throughout storage. The WHC results confirm the correlation ($P < 0.05$) between percentage of flour used and syneresis. The results show higher ($P < 0.05$) WHC values in treatments with a higher amount of flour.

CONCLUSION

The findings indicate that the addition of açaí, beetroot, and hibiscus flours to whey-based cocoa beverages can significantly alter their physicochemical properties and microbial stability. Beetroot flour demonstrated beneficial effects in terms of microbial inhibition and water-holding capacity. These results suggest potential applications in the functional beverage market, where natural additives are sought to enhance nutritional and sensory attributes. Further research is recommended to explore the long-term stability and consumer acceptance of these formulations.

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Table 1. Concentration of ingredients in whey-based cocoa beverages with flour addition.

Treatment	Ingredients (%)					
	Xylitol	Cocoa	caseinate	Xanthan gum	Flour	Whey
Control	3.5	7.5	2.5	0.25	0.0	86.25
BAFL[1]	3.5	7.5	2.5	0.25	0.5	85.75
BAFM	3.5	7.5	2.5	0.25	1.5	84.75
BAFH	3.5	7.5	2.5	0.25	2.5	83.75
BBFL	3.5	7.5	2.5	0.25	0.5	85.75
BBFM	3.5	7.5	2.5	0.25	1.5	84.75
BBFH	3.5	7.5	2.5	0.25	2.5	83.75
BHFL	3.5	7.5	2.5	0.25	0.5	85.75
BHFM	3.5	7.5	2.5	0.25	1.5	84.75
BHFH	3.5	7.5	2.5	0.25	2.5	83.75

Control: without flour; [1]BAF = beverage with açaí flour; BFB = beverage with beetroot flour; BFH = beverage with hibiscus flour; L, beverage (0.5% flour); M, beverage (1.5% flour); H, beverage (2.5% flour).

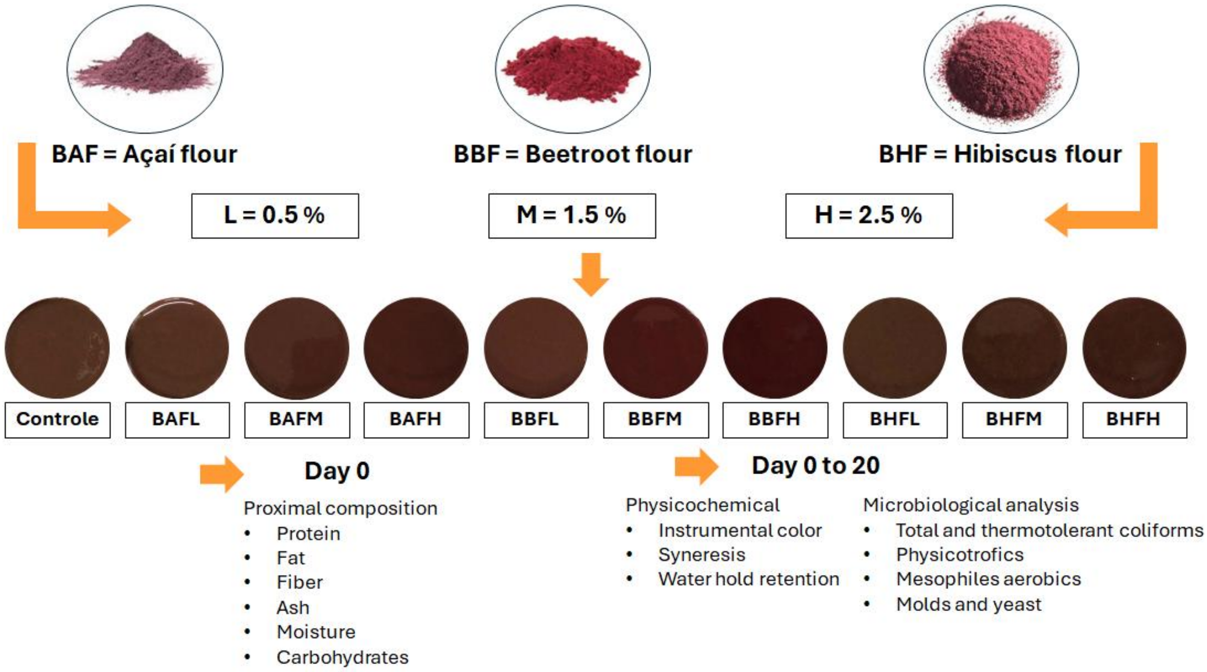

Figure 1. Study design illustrating the stages involved in the experiment of whey-based cocoa beverages. Control: without flour; BAF = beverage with açaí flour; BFB = beverage with beetroot flour; BFH = beverage with hibiscus flour; L, beverage (0.5% flour); M, beverage (1.5% flour); H, beverage (2.5% flour).

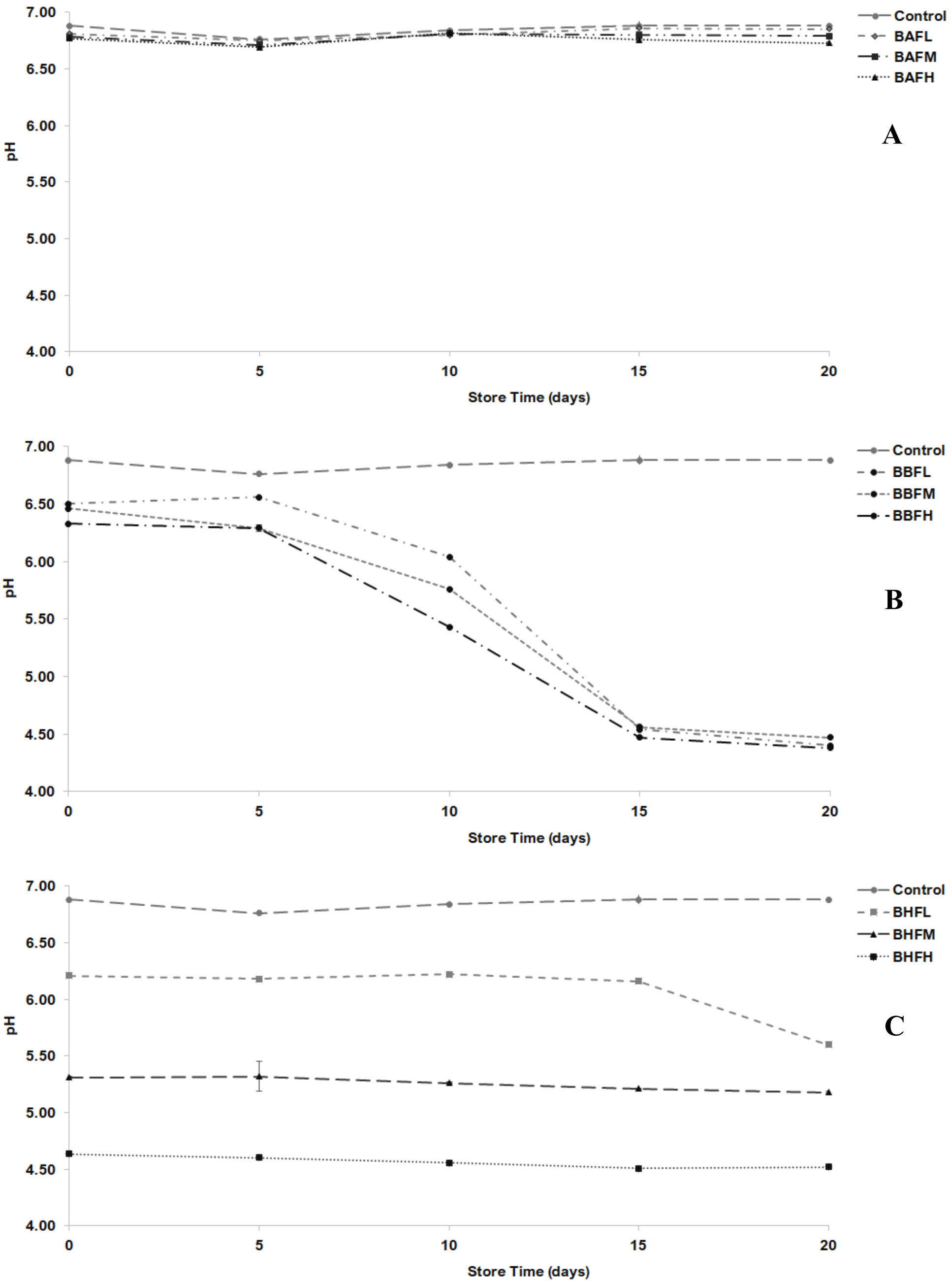

Figure 2. pH means of cocoa whey-based beverages with flour addition as influenced by treatments over 20 d at 4 ºC. **A**: comparation with control and treatments with acai flour addition; **B**: comparation with control and treatments with beetroot flour addition; **C**: comparation with control and treatments with beetroot flour addition. Control: without flour; BAF = beverage with açaí flour; BFB = beverage with beetroot flour; BFH = beverage with hibiscus flour; L, beverage (0.5% flour); M, beverage (1.5% flour); H, beverage (2.5% flour).

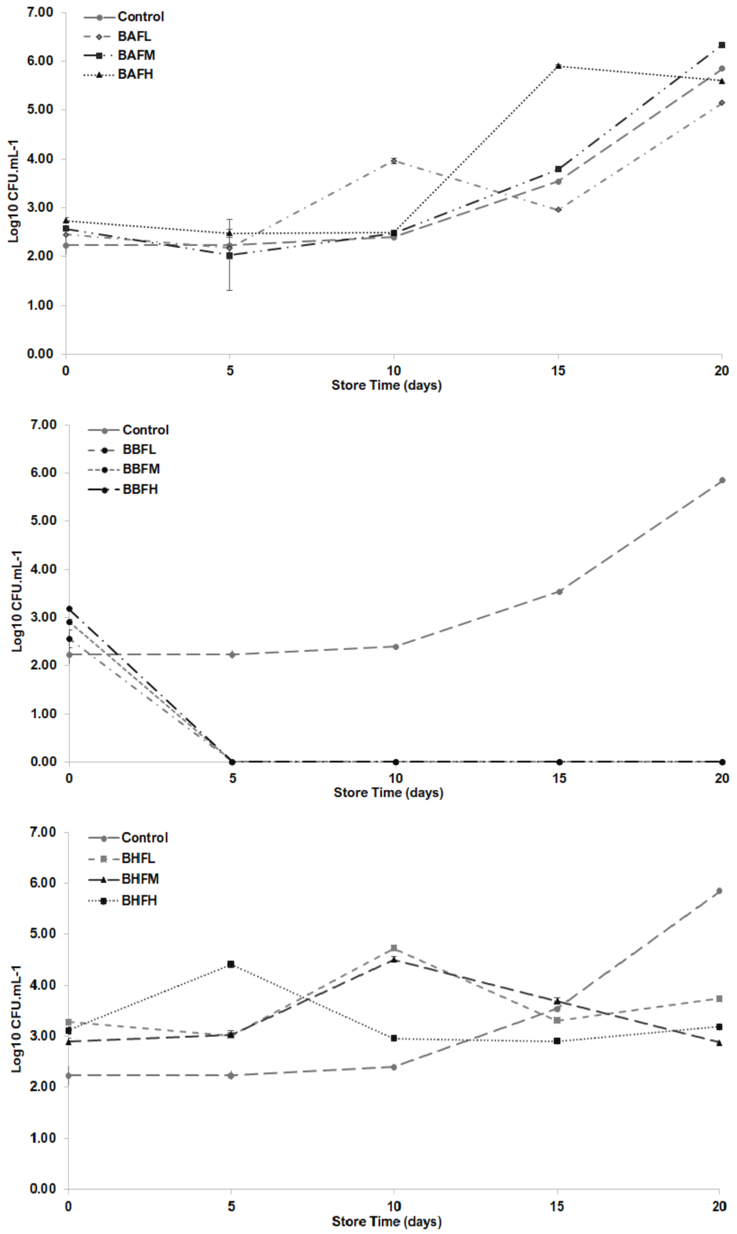

Figure 3. Aerobic mesophiles count in cocoa whey-based beverages with flour addition as influenced by treatments over 20 d at 4 ºC. **A**: comparation with control and treatments with acai flour addition; **B**: comparation with control and treatments with beetroot flour addition; **C**: comparation with control and treatments with beetroot flour addition. Control: without flour; BAF = beverage with açaí flour; BFB = beverage with beetroot flour; BFH = beverage with hibiscus flour; L, beverage (0.5% flour); M, beverage (1.5% flour); H, beverage (2.5% flour)

Table 2. Color parameters values (mean ± DS) of cocoa whey-based beverages with flour addition during 20 d of storage at 4 ◦C.

Attribute	Treatment	d 0	d 5	d 10	d 15	d 20
L*	Control	15.41 ± 1.15^{cC}	20.87 ± 1.60^{cB}	25.45 ± 0.71^{abA}	24.72 ± 0.40^{bA}	24.52 ± 0.76^{bA}
	BAFL[1]	18.21 ± 1.57^{bcC}	24.48 ± 0.58^{aA}	25.28 ± 0.52^{abAB}	27.55 ± 1.92^{aAB}	26.15 ± 0.56^{aA}
	BAFM	19.27 ± 1.06^{abC}	23.12 ± 0.53^{abB}	24.27 ± 0.49^{bcAB}	25.22 ± 0.48^{bA}	23.81 ± 0.18^{bB}
	BAFH	18.33 ± 1.39^{bB}	23.82 ± 0.57^{aA}	23.83 ± 0.66^{bcA}	25.21 ± 0.83^{bA}	23.52 ± 0.26^{bA}
	BBFL	17.94 ± 0.66^{bcC}	23.05 ± 0.96^{bB}	25.65 ± 0.51^{aA}	26.14 ± 0.73^{abA}	24.33 ± 1.31^{bAB}
	BBFM	20.03 ±1.04^{abC}	21.06 ± 0.50^{cBC}	23.34 ± 0.23^{bcA}	24.03 ± 0.26^{bA}	21.82 ± 0.26^{bcB}
	BBFH	17.82 ± 0.31^{bcC}	20.87 ± 1.04^{cB}	20.87 ± 0.39^{cB}	21.93 ± 0.73^{cB}	23.37 ± 0.42^{bcA}
	BHFL	21.78 ± 1.42^{aB}	25.01 ± 0.34^{aA}	26.09 ± 0.51^{aA}	25.40 ± 0.49^{bA}	26.23 ± 0.69^{aA}
	BHFM	20.66 ± 1.48^{abC}	23.57 ± 0.18^{abB}	24.50 ± 0.56^{bAB}	25.63 ± 0.38^{abA}	25.39 ± 0.65^{abA}
	BHFH	19.04 ± 0.96^{abC}	21.88 ± 0.61^{bcB}	23.19 ± 0.06^{dAB}	23.73 ± 0.78^{bcA}	21.68 ± 0.68^{cB}
a*	Control	5.67 ± 0.19^{cC}	7.52 ± 0.70^{dB}	9.79 ± 0.34^{eA}	10.04 ± 0.43^{dA}	9.66 ± 0.22^{cA}
	BAFL	7.15 ± 0.46^{bC}	9.99 ± 0.29^{bB}	10.27 ± 0.43^{deAB}	10.64 ± 0.54^{dAB}	11.17 ± 0.33^{bcA}
	BAFM	8.03 ± 0.41^{bD}	9.94 ± 0.26^{bcC}	10.73 ± 0.26^{dB}	11.90 ± 0.43^{cA}	10.52 ± 0.36^{cBC}
	BAFH	7.91 ± 0.52^{bC}	10.99 ± 0.22^{bB}	11.63 ± 0.36^{cB}	12.87 ± 0.68^{bcA}	11.26 ± 0.38^{bcB}
	BBFL	8.27 ± 0.22^{bC}	11.57 ± 0.43^{abB}	13.00 ± 0.24^{bA}	13.46 ± 0.38^{bA}	11.88 ± 0.78^{bcB}
	BBFM	11.09 ± 1.03^{aC}	12.28 ± 0.77^{aBC}	14.32 ± 0.37^{aA}	15.52 ± 0.51^{aA}	12.66 ± 0.30^{bB}
	BBFH	10.04 ± 0.63^{aD}	12.69 ± 0.80^{aC}	14.41 ± 0.31^{aB}	15.52 ± 0.82^{aB}	17.71 ± 0.94^{aA}
	BHFL	7.63 ± 0.19^{bC}	8.72 ± 0.32^{cB}	9.79 ± 0.32^{eA}	9.72 ± 0.29^{dA}	7.79 ± 0.23^{dC}
	BHFM	7.14 ± 0.64^{bC}	8.44 ± 0.20^{cdB}	9.47 ± 0.36^{eA}	10.28 ± 0.28^{dA}	9.69 ± 0.52^{cA}
	BHFH	7.45 ± 0.57^{bC}	8.77 ± 0.44^{cB}	9.86 ± 0.58de^{AB}	10.66 ± 0.29^{dA}	9.46 ± 0.35^{cB}
b*	Control	4.28 ± 0.23^{abC}	5.76 ± 0.34^{bcB}	8.20 ± 0.45^{aA}	8.84 ± 0.52^{aA}	8.21 ± 0.13^{abA}
	BAFL	4.84 ±0.38^{abC}	7.69 ± 0.53^{aB}	7.89 ± 0.66^{abAB}	8.35 ± 0.99^{abAB}	9.22 ± 0.25^{aA}
	BAFM	4.73 ± 0.25^{abD}	6.15 ± 0.22^{bC}	7.01 ± 0.14^{abB}	8.60 ± 0.70^{aA}	7.01 ± 0.34^{bBC}
	BAFH	3.81 ± 0.03^{bcC}	6.09 ± 0.33^{bB}	6.79 ± 0.25^{abB}	8.15 ± 0.82^{abA}	6.75 ± 0.36^{bcB}
	BBFL	4.56 ± 0.22^{abC}	7.43 ± 0.26^{abB}	8.55 ± 0.41^{aAB}	9.46 ± 0.49^{aA}	8.00 ± 0.74^{abAB}
	BBFM	4.26 ± 0.43^{abC}	5.24 ± 0.56^{cC}	6.78 ± 0.37^{bB}	8.31 ± 0.64^{abA}	6.49 ± 0.42^{cB}
	BBFH	3.04 ± 0.49^{cC}	4.14 ± 0.60^{dC}	6.09 ± 0.14^{bB}	6.85 ± 0.64^{abAB}	7.89 ± 0.81^{abA}
	BHFL	5.11 ± 0.21^{aC}	6.44 ± 0.64^{bB}	7.99 ± 0.43^{abA}	8.11 ± 0.53^{abA}	4.65 ± 0.62^{dC}
	BHFM	4.20 ± 0.42^{bD}	5.46 ± 0.48^{bcC}	6.92 ± 0.49^{bB}	8.12 ± 0.38^{abA}	7.30 ± 0.58^{bAB}
	BHFH	3.83 ± 0.57^{bcB}	4.89 ± 0.70^{cdAB}	6.02 ± 0.69^{bA}	6.82 ± 0.25^{bA}	6.41 ± 0.50^{cA}
C*	Control	7.10 ± 0.24^{cC}	9.53 ± 0.69^{cB}	12.77 ± 0.55^{bcA}	13.37 ± 0.66^{bcA}	12.68 ± 0.25^{cdA}
	BAFL	8.71 ±0.58^{bC}	12.61 ± 0.53^{abB}	12.95 ±0.74^{bB}	13.53 ± 1.03^{bcB}	14.48 ± 0.41^{bAB}
	BAFM	9.32 ± 0.46^{abD}	11.69 ± 0.30^{bC}	12.81 ± 0.29^{bcB}	14.68 ± 0.74^{bA}	12.64 ± 0.49^{cdBC}
	BAFH	8.78 ± 0.48^{bC}	12.57 ± 0.35^{abB}	13.46 ± 0.42^{bB}	15.24 ± 1.00^{bA}	13.07 ± 0.55^{cB}
	BBFL	9.44 ± 0.26^{abC}	13.75 ± 0.49^{aB}	15.54 ± 0.41^{aA}	16.44 ± 0.57^{abA}	13.58 ± 1.20^{bcB}
	BBFM	11.88 ± 1.12^{aC}	13.35 ± 0.92^{aBC}	15.85 ± 0.49^{aB}	17.65 ± 0.76^{aA}	14.33 ± 0.48^{bcC}
	BBFH	10.48 ± 0.74^{abD}	13.35 ± 0.92^{aC}	15.65 ± 0.32^{aB}	16.97 ± 0.98^{abB}	19.34 ± 1.26^{aA}
	BHFL	9.05 ± 0.40^{abC}	10.84 ± 0.64^{bcB}	12.63 ± 0.51^{bcA}	12.67 ± 0.55^{cA}	9.07 ± 0.49^{eC}
	BHFM	8.29 ± 0.76^{bcC}	10.06 ± 0.42^{cB}	11.73 ± 0.57^{bcA}	13.06 ± 0.50^{bcA}	12.13 ± 0.76^{cdA}
	BHFH	8.40 ± 0.71^{bcC}	10.09 ± 0.70^{cB}	11.68 ± 0.63^{cA}	12.65 ± 0.35^{cA}	11.45 ± 0.55^{cdA}
h*	Control	36.99 ± 1.43^{aB}	37.23 ± 0.82^{aB}	39.70 ± 1.02^{aA}	41.33 ± 0.50^{aA}	40.36 ± 0.24^{aA}
	BAFL	34.10 ± 0.71^{bB}	37.58 ± 1.32^{aA}	37.46 ± 1.22^{abA}	38.01 ± 1.97^{bA}	39.52 ± 0.36^{abA}
	BAFM	30.48 ± 0.79^{cC}	31.73 ± 0.82^{bcBC}	33.19 ± 0.23^{cB}	35.83 ± 1.36^{bcA}	33.67 ± 0.44^{cB}
	BAFH	25.76 ± 1.30^{dC}	28.98 ± 0.84^{cB}	30.27 ± 0.48^{dAB}	32.27 ± 1.47^{dA}	30.56 ± 0.87^{dAB}
	BBFL	28.87 ± 1.14^{cdC}	32.73 ± 0.52^{bB}	33.35 ± 0.93^{cAB}	35.04 ± 0.74^{cA}	33.91 ± 0.92^{cAB}

	BBFM	21.04 ± 0.50^{eD}	23.03 ± 1.00^{dC}	25.31 ± 0.69^{eB}	28.13 ± 1.11^{eA}	26.76 ± 0.82^{eAB}
	BBFH	16.75 ± 1.69^{fB}	18.03 ± 1.67^{eB}	22.98 ± 0.55^{fA}	23.56 ± 0.90^{fA}	23.96 ± 1.13^{fA}
	BHFL	34.42 ± 0.72^{abB}	36.39 ± 1.73^{aAB}	39.20 ± 0.71^{abAB}	39.81 ± 1.07^{abA}	30.62 ± 2.35^{dC}
	BHFM	30.45 ± 0.49^{cC}	32.87 ± 1.71^{bB}	36.12 ± 1.04^{bA}	38.29 ± 0.54^{bA}	36.97 ± 0.76^{bA}
	BHFH	27.55 ±1.76^{dB}	28.89 ± 2.57^{cAB}	31.33 ± 1.50^{cdAB}	32.59 ± 0.62^{cdA}	34.01 ± 1.39^{cA}
ΔE	Control	---	5.97 ± 0.82^{bcB}	11.54 ± 1.87^{aA}	11.28 ± 1.09^{aA}	10.72 ± 1.87^{aA}
	BAFL	---	7.52 ± 1.74^{aA}	10.62 ± 2.94^{abA}	10.62 ± 2.94^{abA}	9.93 ± 1.25^{abA}
	BAFM	---	4.53 ± 0.59^{bcdB}	6.14 ± 1.47^{bAB}	8.09 ± 1.62^{bA}	5.69 ± 0.88^{cAB}
	BAFH	---	6.73 ± 1.79^{abA}	7.28 ± 1.40^{abA}	9.55 ± 2.02^{abA}	6.90 ± 1.11^{bcA}
	BBFL	---	6.73 ± 0.46^{bB}	9.91 ± 0.98^{abAB}	10.88 ± 1.14^{abA}	8.13 ± 2.03^{bAB}
	BBFM	---	2.33 ± 1.32^{dB}	5.28 ± 1.83^{bAB}	7.25 ± 1.24^{bcA}	3.31 ± 1.62^{cB}
	BBFH	---	4.34 ± 1.33^{bcdC}	6.17 ± 0.36^{bBC}	7.90 ± 1.33^{bB}	10.66 ± 1.40^{abA}
	BHFL	---	3.77 ± 1.29^{cA}	5.68 ± 1.10^{bA}	5.21 ± 1.29^{cA}	4.49 ± 1.76^{cA}
	BHFM	---	3.48 ± 1.38d^{cB}	5.30 ± 1.12^{bAB}	7.10 ± 1.67^{bcA}	6.23 ± 2.02^{bcAB}
	BHFH	---	3.40 ± 0.74^{cdB}	5.36 ± 1.60^{bAB}	6.45 ± 1.36^{bcA}	4.33 ± 1.39^{cAB}

$^{a–f}$ Different lowercase letters in the same column indicate significant differences among treatments of whey-based cocoa beverages ($P < 0.05$). $^{A–D}$ Different capital letters in the same lines indicate significant differences among treatments of whey-based cocoa beverages ($P < 0.05$). Control: without flour; [1]BAF = beverage with açaí flour; BFB = beverage with beetroot flour; BFH = beverage with hibiscus flour; L. beverage (0.5% flour); M. beverage (1.5% flour); H. beverage (2.5% flour).

Table 3. Syneresis and water-holding capacity (mean ± DS) of cocoa whey-based beverages with flour addition during 20 d of storage at 4 ºC.

Attribute	Treatment	d 0	d 5	d 10	d 15	d 20
Syneresis	Control	62.49 ± 1.22^{abA}	61.97 ± 1.91^{bA}	61.95 ± 0.28^{cA}	62.17 ± 1.26^{cdA}	64.70 ± 1.12^{cdA}
	BAFL[1]	65.51 ± 1.24^{abAB}	60.04 ± 1.68^{bB}	60.84 ± 0.63^{cB}	62.61 ± 1.31^{cdAB}	66.59 ± 0.41^{bA}
	BAFM	61.32 ± 2.05b^{BC}	59.61 ± 0.70^{bC}	61.30 ± 0.22^{cBC}	62.76 ± 0.80^{cdB}	66.81 ± 0.47^{bcA}
	BAFH	58.95 ± 2.17^{bcC}	56.07 ± 0.68^{cC}	66.94 ± 0.68^{bA}	58.40 ± 0.77^{eC}	63.03 ± 0.95^{dB}
	BBFL	54.96 ± 1.67^{cB}	48.02 ± 0.85^{dD}	51.25 ± 0.08^{dC}	64.37 ± 0.72^{cA}	64.97 ± 1.03^{edA}
	BBFM	46.35 ± 1.87^{dC}	31.25 ± 0.64^{eD}	33.81 ± 0.85^{eD}	60.15 ± 0.08^{deB}	66.22 ± 0.95^{cA}
	BBFH	41.41 ± 2.53^{dB}	29.17 ± 0.29^{eC}	30.90 ± 0.79^{fC}	61.09 ± 0.32^{dA}	64.45 ± 1.12^{cdA}
	BHFL	70.97 ± 0.72^{aB}	68.44 ± 1.30^{aC}	71.56 ± 0.85^{aB}	73.95 ± 0.64^{aA}	71.49 ± 0.58^{aA}
	BHFM	67.32 ± 1.46^{abB}	67.94 ± 0.82^{aAB}	70.06 ± 0.06^{aA}	69.10 ± 0.85^{bAB}	68.96 ± 0.39^{bAB}
	BHFH	64.27 ± 1.42^{abB}	66.91 ± 0.89^{aA}	61.02 ± 0.60^{cC}	67.47 ± 0.62^{bA}	68.31 ± 0.52^{bcA}
WHC	Control	37.51 ± 1.22^{cdA}	38.03 ± 1.91^{dA}	38.05 ± 0.28^{dA}	37.83 ± 1.26^{bcA}	35.30 ± 1.12^{abA}
	BAFL	34.49 ± 1.24^{dAB}	39.96 ± 1.68^{dA}	39.16 ± 0.63^{dA}	37.39 ± 1.31^{bcAB}	33.41 ± 0.41^{bA}
	BAFM	38.68 ± 2.05^{cAB}	40.39 ± 0.70^{dA}	38.70 ± 0.22^{dAB}	37.24 ± 0.80^{bcA}	33.19 ± 0.47^{bcC}
	BAFH	41.05 ± 2.17^{bcA}	43.93 ± 0.68^{cA}	33.06 ± 0.68^{eC}	41.60 ± 0.77^{aA}	36.97 ± 0.95^{aB}
	BBFL	45.04 ± 1.67^{bC}	51.98 ± 0.85^{bA}	48.75 ± 0.08^{cB}	35.63 ± 0.72^{cD}	35.03 ± 1.03^{abD}
	BBFM	53.65 ± 1.87^{aB}	68.75 ± 0.64^{aA}	66.19 ± 0.85^{bA}	39.85 ± 0.08^{abC}	33.78 ± 0.95^{bD}
	BBFH	58.59 ± 2.53^{aB}	70.83 ± 0.29^{aA}	69.10 ± 0.73^{aA}	38.91 ± 0.32^{bC}	35.55 ± 1.12^{abC}
	BHFL	29.03 ± 0.72^{eB}	31.56 ± 1.30^{eA}	28.44 ± 0.85^{fB}	26.05 ± 0.64^{eC}	28.51 ± 0.58^{dB}
	BHFM	32.68 ± 1.46d^{eA}	32.06 ± 0.82^{eAB}	29.94 ± 0.06^{fB}	30.90 ± 0.85^{dAB}	31.04 ± 0.39^{cAB}
	BHFH	35.73 ± 1.42^{dB}	33.09 ± 0.89^{eC}	38.98 ± 0.60^{dA}	32.53 ± 0.62^{dC}	31.69 ± 0.52^{bcC}

$^{a–f}$Different lowercase letters in the same column indicate significant differences among treatments of whey-based cocoa beverages ($P < 0.05$). $^{A–D}$Different capital letters in the same lines indicate significant differences among treatments of whey-based cocoa beverages ($P < 0.05$). Control: without flour; [1]BAF = beverage with açaí flour; BFB = beverage with beetroot flour; BFH = beverage with hibiscus flour; L. beverage (0.5% flour); M. beverage (1.5% flour); H. beverage (2.5% flour).

8 CONSIDERAÇÕES FINAIS

A produção de bebidas à base de soro de leite se considera uma alternativa promissora ao aproveitamento de resíduos da indústria láctea, devido à sua fácil produção e à exigência de equipamentos elementares. Menor pH observou-se nas bebidas com adição de polpa de frutas (morango, graviola e cacau), o que por sua vez contribuiu no aumento da aceitação e dos atributos sensoriais das bebidas à base de soro de leite de cabra. Além disso, os consumidores conseguiram identificar as características específicas de cada polpa de fruta e, devido à sua maior familiaridade, os tratamentos com polpa de morango foram mais aceitos. No entanto, o presente estudo demostrou os benefícios de utilizados o soro de leite como base principal na produção de bebidas, permitindo maior aproveitamento do soro de leite.

Em comparação, as bebidas de cacau à base de soro de búfala e bovino, apresentaram maiores níveis de aceitação quando o cacau em pó foi utilizado em menores proporções e combinado com açúcar de cana. Além disso, as bebidas contendo 100 % de cacau enfrentaram penalidades devido ao aroma inadequado e à doçura insuficiente. Notavelmente, o tipo de informação fornecida aos consumidores teve um impacto significativo nas suas respostas emocionais, mostrando o papel da informação na formação das percepções do consumidor. Além disso, a adição de farinhas de açaí, beterraba e hibisco nas bebidas de cacau à base de soro de leite pode alterar significativamente suas propriedades físico-químicas e estabilidade microbiana. A farinha de beterraba demonstrou efeitos benéficos em termos de inibição microbiana e capacidade de retenção de água.

Os resultados do presente estudo sugerem potenciais aplicações no mercado de bebidas funcionais, onde aditivos naturais são procurados para melhorar os atributos nutricionais e sensoriais.

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PRODUTOS GERADOS.

Ao longo do programa de doutorado foi publicado um artigo científico e um deposito de patente, além disso, colaborei em outros trabalhos, nos quais sou autor ou coautor, seguem abaixo:

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Article

Buffalo Whey-Based Cocoa Beverages with Unconventional Plant-Based Flours: The Effect of Information and Taste on Consumer Perception

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Abstract: This study aimed to evaluate the addition of açaí, beetroot, and hibiscus flour on the sensory characteristics of a buffalo whey-based cocoa beverage and, second, to consider if health and sustainability claims could enhance consumer acceptance and purchase intention for the buffalo whey-based cocoa beverage. In this sense, five treatments were elaborated; BCC, the control with a commercial beverage formulation; BCE, the experimental control; BFA, with the addition of açaí flour; BFB, with added beetroot flour; and BFH, with the addition of hibiscus flour. The experiment was divided into two stages: In the first, the beverages were submitted to sensory analyses of acceptance (nine-point hedonic scale), purchase intention and just-about-right (five points), and check-all-that-apply (CATA). In the second stage, the beverages with the highest and lowest acceptance rates were taken, and they were subjected to the effect of sustainability and health information on consumer acceptance, purchase intention, and the CATA test using terms referring to emotions and feelings. The addition of flours decreased the beverage acceptance rate compared to the BCC treatment. The treatments were penalized in aroma and sweet taste. There was no effect on the type of information received by the consumer. Probably, the addition of high cocoa percentages can negatively affect the acceptance of products, as well as the use of flour with bitter flavors, due to the greater acceptance of sweeter products.

Keywords: consumer perception; buffalo whey; by-products; chocolate flavor; sustainability; beverage

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1. Introduction

Whey, a prominent by-product of the dairy industry, holds a significant position in annual dairy production, generating over 60 million liters. In the northeast region of Brazil, the production of coalho cheese stands out, obtained from rennet and matured for 10 days, and has a yield of approximately 1 kilo of coalho cheese per 10 L of milk, which generates approximately 9 L of whey [1]. However, this substantial volume of whey production has been accompanied by growing environmental concern since more than 50% of this valuable resource is traditionally discarded [2]. This wasteful practice has far-reaching environmental implications, ranging from water pollution to greenhouse gas emissions [3]. In light of these environmental challenges, there is a pressing need to reassess the role of

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Dados do Depositante (71)

Depositante 1 de 1

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Brazilian Journal of Development

Low-fat cupuassu goat milk yogurt optimization by just-about-right scale

Otimização de iogurte de leite de cabra de cupuaçu com baixo teor de gordura em uma escala quase certa

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ABSTRACT
Goat milk products have been characterized by unusual consumers with lower acceptance due to their

applied sciences

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Communication

Effect of Sonication Associated with Pasteurization on the Inactivation of Methicillin-Resistant *Staphylococcus aureus* in Milk Cream

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Abstract: Methicillin-resistant *Staphylococcus aureus* (MRSA) poses a significant challenge to the dairy industry, necessitating robust strategies to ensure food safety. This study focuses on the efficacy of thermosonication, a novel technology combining ultrasound and heat, in reducing MRSA in milk cream. Comparative analysis is conducted with conventional pasteurization, the industry standard. Results indicate that thermosonication effectively reduces MRSA counts by up to 4.72 log CFU/mL, akin to pasteurization's reduction of 4.82 log CFU/mL. This finding highlights the potential of thermosonication as a rapid, energy-efficient alternative to pasteurization in the dairy industry, significantly reducing processing time while maintaining microbial safety. Further exploration and optimization of these techniques promise enhanced food safety and quality control in dairy products, addressing the growing concern of antibiotic-resistant strains like MRSA. This research lays a foundation for innovative approaches and underscores the significance of quantitative data in food safety research.

Keywords: MRSA; ultrasound; thermosonication; bacterial reduction; food safety

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1. Introduction

Milk cream holds a significant place within the realm of dairy products in the diets of Brazilians, primarily due to its versatility. It plays a pivotal role as an essential ingredient in a diverse spectrum of culinary preparations, serving as an integral component in various sweet and savory dishes [1]. It is worth noting that creams available on the Brazilian market exhibit discernible disparities, primarily stemming from variances in their heat treatment processes and fat content. Among the available options, UHT (Ultra-High Temperature) creams, characterized by an average fat content of 20%, offer a unique proposition [2]. These creams undergo processing that imparts an extended shelf life and allows them to be stored at ambient temperatures until opened, enhancing their convenience and accessibility. In contrast, pasteurized creams, which, on average, contain approximately 35% fat, represent a distinct category [2].

The pasteurization process entails subjecting the cream to a specific temperature for a predetermined duration, thereby ensuring the elimination of harmful microorganisms

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RESEARCH ARTICLE

Assessment of plain yoghurt quality parameters affected by milk adulteration: Implications for culture kinetics, physicochemical properties, and sensory perception

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In developing nations, the widespread practice of adulterating milk with water, driven by economic motives, poses a significant threat to milk derivatives like yoghurt. Despite the absence of mandatory water detection tests for plain yoghurt, our study investigated the repercussions of adding 0–15% water to milk on plain yoghurt quality parameters over 28 days of refrigerated storage. Starter culture kinetics were notably affected, influencing colour and texture. Yet, sensory analysis indicated minimal impact on consumer perception. These results underscore the potential risk of unknowingly consuming adulterated yoghurt, emphasising the necessity for stringent regulatory measures to counteract such practices.

Keywords Milk adulteration, Yoghurt composition, Yoghurt quality, Microbial modelling, Food safety, Food fraud.