

SENSORY EVALUATION OF GLUTEN-FREE BAKERY PRODUCTS USING ALTERNATIVE FLOURS

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ABSTRACT

The increasing demand for gluten-free bakery products has encouraged researchers and food manufacturers to explore alternative flours that can replace conventional wheat flour while maintaining desirable sensory characteristics. This study focuses on the sensory evaluation of gluten-free bakery products prepared using alternative flours such as rice, sorghum, millet, buckwheat, teff, and quinoa. The study aims to evaluate consumer responses to the sensory characteristics of different gluten-free bakery formulations, including appearance, colour, aroma, taste, texture, mouthfeel, and overall acceptability. A quantitative research approach with an experimental research design is proposed. Different bakery products will be prepared using selected gluten-free flour formulations, while a control formulation may be included for comparison. Sensory evaluation will be conducted using a structured nine-point hedonic scale involving selected sensory panelists. The collected data will be analysed using descriptive statistics, mean scores, standard deviations, and appropriate statistical tests such as one-way ANOVA. Previous research demonstrates that flour type and substitution level can significantly influence flavour, texture, volume, colour, and consumer acceptance. For example, sorghum, teff, and yacon combinations have produced gluten-free bread with favourable sensory characteristics, while recent work has also demonstrated consumer acceptance of gluten-free products prepared with buckwheat and other alternative flours. The study is expected to contribute to the development of acceptable, nutritious, and commercially viable gluten-free bakery products.

KEYWORDS: *Gluten-free products, alternative flours, sensory evaluation, bakery products, consumer acceptance, sorghum, rice flour, buckwheat, teff.*

INTRODUCTION

Gluten-free bakery products have received increasing attention because of the dietary requirements of people with celiac disease, gluten sensitivity, wheat allergy, and consumers who voluntarily reduce gluten consumption. Iwamura, L. S. (2023).found that Wheat flour is traditionally used in bakery production because gluten provides important structural and functional properties to dough and baked products. When wheat flour is removed, manufacturers face difficulties in obtaining the desired volume, softness, elasticity, texture, appearance, and eating quality. Therefore, the identification of suitable gluten-free alternative flours has become an important area of food product development. Recent research emphasizes that replacing wheat flour requires careful consideration of both technological properties and sensory quality. Rice flour is one of the most commonly used ingredients in gluten-free bakery products because of its relatively mild flavour and suitable processing characteristics. However, relying exclusively on rice flour may result in products with limited nutritional diversity and undesirable textural characteristics. Cabrera, V. D. C. (2026). explained Consequently, researchers have investigated alternative ingredients such as sorghum, teff, millet, buckwheat, quinoa, legumes, and other functional flours. A 2025 review of gluten-free cookies reported that rice flour and starches are widely used, while ingredients such as amaranth, quinoa, and sorghum can provide nutritional and functional advantages but may also require adjustments to texture and flavour. Sorghum is particularly promising because it is naturally gluten-free and can contribute minerals, antioxidants, and distinctive sensory characteristics to bakery products. Research published in 2023 found that

increasing white sorghum flour in gluten-free bread influenced colour, flavour, graininess, roughness, chewiness, and other textural characteristics. The researchers reported that a moderate level of sorghum could provide an acceptable balance between bread volume and texture.

Similarly, recent research on sorghum-containing gluten-free cookies found generally favourable sensory responses while demonstrating potential nutritional benefits. Teff, buckwheat, millet, quinoa, and other alternative flours may also provide opportunities for improving gluten-free bakery products. Their incorporation can change the sensory profile of products because each flour has different colour, aroma, flavour, particle size, starch characteristics, protein content, and water absorption properties. A 2023 study examining gluten-free bread made with sorghum, teff, and yacon reported that a combined formulation received favourable overall acceptance and produced desirable characteristics such as pleasant aroma, sweet taste, crumb texture, and porosity. Bhattacharya, D., Singha, P. S., Firdaus, S. B., & Ghosh, D. (2023). explains Another 2023 study developed gluten-free orange-flavoured cakes using rice, sorghum, teff, and yacon and found that an optimized formulation achieved good sensory acceptance. Sensory evaluation is therefore an essential component of gluten-free product development. Nutritional improvement alone does not guarantee market success because consumers generally expect bakery products to have attractive appearance, pleasant aroma, desirable taste, soft or appropriate texture, and overall palatability. Sensory evaluation allows researchers to determine whether consumers accept a product and which sensory characteristics contribute to or reduce acceptance. Recent studies have used hedonic testing, descriptive analysis, Flash Profile, Just About Right, and CATA/RATA approaches to evaluate gluten-free bakery products. The present study therefore proposes to evaluate the sensory characteristics of gluten-free bakery products prepared using different alternative flours.

The research will focus on appearance, colour, aroma, taste, texture, mouthfeel, and overall acceptability. The findings can provide useful information for food researchers, bakery manufacturers, culinary professionals, and consumers interested in acceptable gluten-free alternatives. The growing interest in healthy, functional, and specialized food products has significantly increased the demand for gluten-free bakery products around the world. Gluten-free foods were initially developed mainly for individuals diagnosed with celiac disease, gluten sensitivity, or wheat-related disorders; however, their consumption has gradually expanded among consumers who perceive gluten-free products as suitable alternatives within health-conscious diets. Bakery products such as bread, biscuits, cookies, cakes, muffins, and pastries are traditionally manufactured using wheat flour because wheat contains gluten-forming proteins that provide elasticity, structure, cohesiveness, and gas-retention properties to dough. When wheat flour is excluded from bakery formulations, these important functional properties are reduced, making the development of acceptable gluten-free products a significant technological challenge. Consequently, researchers and food manufacturers have increasingly investigated alternative gluten-free flours that can replace wheat flour while producing bakery products with satisfactory nutritional, physical, and sensory characteristics. Irigoytia, K. F., Espósito, N. N., de Escalada Pla, M. F., Parodi, M. B., & Genevois, C. E. (2024). revealed Gluten is a complex protein network formed primarily from glutenin and gliadin proteins when wheat flour is mixed with water. This network provides the structural framework required for many conventional bakery products. During fermentation and baking,

gluten helps retain carbon dioxide produced by yeast or chemical leavening agents, contributing to the volume and characteristic crumb structure of bread and other baked products. In gluten-free formulations, the absence of this network can result in products with low volume, poor elasticity, excessive crumbliness, dense texture, rapid staling, and undesirable mouthfeel. Therefore, the replacement of wheat flour with alternative flours cannot simply involve selecting a flour that is naturally gluten-free. The alternative flour must also contribute appropriate functional properties and, ideally, produce sensory characteristics that consumers find acceptable. The development of gluten-free bakery products has therefore become an important area of food science and product development. Researchers have investigated a wide range of naturally gluten-free cereals, pseudocereals, legumes, roots, and other plant-based materials as alternatives to wheat flour.

Commonly investigated alternatives include rice, maize, sorghum, millet, buckwheat, quinoa, teff, amaranth, chickpea, lentil, and various starches. Each alternative flour has a distinctive nutritional composition and functional behaviour, which can influence the quality of the final baked product. For example, rice flour generally has a relatively mild flavour and light colour, while sorghum may contribute a stronger cereal or nutty flavour and darker colour. Buckwheat can provide a distinctive flavour and nutritional benefits, whereas quinoa may contribute proteins, minerals, and other bioactive compounds. These differences make flour selection an important factor in determining the sensory quality and consumer acceptance of gluten-free bakery products. Rice flour is among the most frequently used alternatives in gluten-free bakery production because of its availability, relatively neutral taste, light colour, and technological suitability for many formulations. Nevertheless, products prepared primarily from rice flour may have limitations related to texture, structure, nutritional diversity, and moisture retention. For this reason, researchers have explored combinations of rice flour with other alternative flours and functional ingredients. Blending different gluten-free flours may provide an opportunity to balance their individual strengths and weaknesses. A flour with a mild flavour can potentially be combined with another flour that provides greater nutritional value, fibre, protein, or structural functionality. The resulting formulation may produce a better balance of sensory and nutritional characteristics than a single-flour formulation. Sorghum is another important alternative flour that has attracted considerable research attention. It is naturally gluten-free and can provide dietary fibre, minerals, phenolic compounds, and other bioactive components. Sorghum flour can be incorporated into bread, biscuits, cookies, cakes, and other bakery products.

However, its characteristic flavour, colour, and particle properties may influence consumer perception. Recent research has demonstrated that increasing the proportion of sorghum flour in gluten-free bread can influence colour, graininess, roughness, chewiness, flavour, and other sensory characteristics. This illustrates that the nutritional or functional advantages of an alternative flour must be considered alongside its sensory effects when developing consumer-oriented bakery products. Millet is also increasingly being explored as a gluten-free alternative because of its nutritional value and adaptability to different food applications. Millet flour can provide carbohydrates, dietary fibre, minerals, and various bioactive compounds.

RESEARCH OBJECTIVE

1. To develop gluten-free bakery products using selected alternative flours.

RESEARCH QUESTION

1. How do alternative flours affect the appearance, colour, aroma, taste, and texture of gluten-free bakery products?

LITERATURE REVIEW

The development of gluten-free bakery products has received increasing attention because of the growing demand for gluten-free foods among individuals with celiac disease, gluten sensitivity, wheat allergy, and consumers seeking dietary alternatives. Gluten is a structural protein found mainly in wheat, barley, and rye, and it plays an important role in bakery products by providing elasticity, gas retention, dough strength, and desirable texture. When gluten is removed, bakery products often experience changes in volume, softness, structure, color, flavor, and overall acceptability. Kawamura, W., Yazawa, R., Takeuchi, Y., Kamio, S., Ichida, K., Hattori, R. S., ... & Yoshizaki, G. (2024).found that . Therefore, researchers have increasingly explored alternative flour sources such as rice, maize, sorghum, millet, buckwheat, chickpea, lentil, quinoa, and other legumes to improve the nutritional and sensory characteristics of gluten-free bakery products. Sensory evaluation is particularly important because nutritional improvement alone does not guarantee consumer acceptance. Rice flour is among the most commonly investigated alternative flours for gluten-free bakery applications because of its mild flavor, light color, availability, and relatively good consumer acceptance. Rice flour can be used in cakes, cookies, muffins, and bread, either alone or in combination with other ingredients. Studies have reported that rice-based gluten-free products generally have acceptable flavor and color, although products prepared exclusively with rice flour may have weaknesses in structure, moisture retention, and mouthfeel. The absence of gluten can produce a crumbly or dry texture, particularly in bread and cookies. Consequently, researchers frequently combine rice flour with starches, hydrocolloids, proteins, or other alternative flours to improve sensory properties. From a sensory perspective, color, aroma, taste, texture, and overall acceptability are commonly evaluated to determine the most appropriate formulation. Maize or corn flour is another important alternative flour used in gluten-free bakery products.

It contributes a characteristic yellowish color, distinctive flavor, and nutritional components such as carbohydrates, dietary fiber, minerals, and bioactive compounds. The inclusion of maize flour can influence sensory characteristics considerably. Moderate levels may provide desirable color and flavor, whereas excessive incorporation can produce a strong corn flavor and a comparatively coarse texture. Researchers therefore emphasize the importance of optimizing the proportion of maize flour in bakery formulations. Sensory panels generally assess attributes such as appearance, color, aroma, taste, crispness or softness, mouthfeel, and overall acceptability. The results indicate that consumer preference can vary according to flour concentration and the type of bakery product being developed.Sorghum flour has also attracted considerable interest in gluten-free product development. Sorghum is naturally gluten-free and provides dietary fiber, minerals, antioxidants, and other nutritional

components. Its incorporation into bakery products can improve nutritional value while offering an alternative to conventional wheat flour. However, sorghum may affect sensory quality because of its characteristic flavor and the presence of phenolic compounds in some varieties. Higher levels of sorghum flour may produce darker color, stronger flavor, and changes in texture. Consequently, blending sorghum with lighter-tasting flours or starches is frequently considered to achieve a balance between nutritional benefits and sensory acceptability Choi, I. R., Chen, Y., Shah, A., Florian, J., Serrao, C., Holoubek, J., ... & Bao, Z. (2025).found that. Sensory evaluation provides an important method for determining the level at which sorghum can be incorporated without negatively affecting consumer preference.

Millet flour represents another promising alternative for gluten-free bakery products. Different millet varieties contain dietary fiber, minerals, proteins, and bioactive compounds, making them nutritionally valuable ingredients. Millet flour can contribute a distinctive flavor and color to baked products. Research on millet-based bakery products indicates that sensory quality depends strongly on the variety of millet, particle size, processing method, and proportion used in the formulation. On the other hand, controlled incorporation of millet flour can produce products with acceptable taste, aroma, color, and texture while improving nutritional characteristics. Therefore, sensory evaluation is essential for identifying formulations that achieve an appropriate balance between nutritional enhancement and consumer acceptability. Buckwheat is also widely studied as a gluten-free ingredient because of its nutritional composition and bioactive compounds. Although buckwheat is not a cereal, its flour can be used in a variety of bakery products. It provides protein, minerals, fiber, and phenolic compounds. However, buckwheat has a distinctive earthy or nutty flavor that can influence consumer acceptance. When incorporated at moderate levels, this flavor may contribute positively to the sensory profile of certain products, while excessive quantities may reduce acceptability. The color of buckwheat flour can also result in darker bakery products. Sensory evaluation therefore helps researchers identify suitable incorporation levels and determine whether consumers prefer buckwheat-containing products over other gluten-free alternatives.

Legume-based flours such as chickpea, lentil, pea, and bean flour have received increasing attention because they can improve the protein, fiber, mineral, and overall nutritional content of gluten-free bakery products. Chickpea flour, for example, can contribute protein and a characteristic nutty flavor. Its incorporation into cookies, crackers, cakes, and other products has been investigated as a strategy for improving the nutritional profile of gluten-free foods. However, higher concentrations may produce a strong legume flavor and affect texture. Lentil and pea flours can similarly increase protein and fiber content, but their sensory characteristics depend on processing conditions and formulation. Roasting, milling, blending, and other processing techniques can modify flavor and reduce undesirable sensory characteristics. Sensory evaluation is therefore necessary to establish acceptable substitution levels. Quinoa flour has emerged as another alternative ingredient because of its high-quality protein, minerals, dietary fiber, and bioactive components. Gluten-free bakery products containing quinoa flour may have improved nutritional value compared with products prepared primarily from refined starches. However, quinoa can possess a characteristic flavor that may influence consumer acceptance. The use of appropriate processing techniques and blending with other flours can help moderate this flavor. Sensory evaluation studies

commonly examine appearance, flavor, texture, aroma, and overall acceptability. These studies demonstrate that the nutritional advantages of quinoa need to be considered alongside its influence on sensory characteristics when developing commercially acceptable gluten-free products. The sensory quality of gluten-free bakery products is strongly associated with texture. Gluten normally creates a continuous protein network that traps carbon dioxide during baking and contributes to the volume and elastic structure of bread and other baked products.

METHODOLOGY

This study will employ a quantitative research approach because the sensory characteristics of the gluten-free bakery products will be measured numerically through structured sensory evaluation. The approach will allow the researcher to collect measurable responses from sensory panelists regarding appearance, colour, aroma, taste, texture, mouthfeel, and overall acceptability. A nine-point hedonic scale can be used, ranging from 1 = dislike extremely to 9 = like extremely. Similar sensory approaches have been used in recent gluten-free bakery research to measure consumer acceptance and sensory characteristics. The present study will employ a quantitative experimental methodology to evaluate the sensory characteristics and overall acceptability of gluten-free bakery products prepared using different alternative flours. The methodology is designed to systematically investigate how the incorporation of naturally gluten-free flours affects important sensory attributes such as appearance, colour, aroma, taste, texture, mouthfeel, and overall acceptability. The study will involve the development of different gluten-free bakery formulations, controlled preparation and baking of the products, sensory evaluation by selected panelists, and statistical analysis of the collected sensory data. The experimental procedure will be maintained under controlled conditions to ensure that differences in sensory responses can be associated primarily with the flour formulations rather than variations in preparation or serving conditions. The present study will employ a quantitative experimental methodology to evaluate the sensory characteristics and overall acceptability of gluten-free bakery products prepared using different alternative flours. The methodology is designed to systematically investigate how the incorporation of naturally gluten-free flours affects important sensory attributes such as appearance, colour, aroma, taste, texture, mouthfeel, and overall acceptability.

RESEARCH DESIGN

An experimental research design will be used. Different gluten-free bakery formulations will be prepared by replacing conventional wheat flour with selected gluten-free alternative flours. Possible formulations may include rice flour, sorghum flour, millet flour, buckwheat flour, or teff flour. A control formulation may also be developed using a standard gluten-free flour blend. Each formulation will be prepared under similar baking conditions so that differences in sensory evaluation can primarily be associated with the flour formulation. The developed products will be coded with random numbers and presented to panelists in a controlled sensory evaluation environment. Recent studies have similarly used different flour formulations and sensory testing to determine the effects of alternative flours on gluten-free bread, cakes, cookies, and other bakery products. The study will use an experimental research design. Different gluten-free bakery products will be prepared by replacing conventional wheat flour with selected alternative gluten-free flours. Possible flour treatments may include

rice flour, sorghum flour, millet flour, buckwheat flour, and teff flour. Depending on the specific bakery product selected for the experiment, either individual alternative flours or carefully designed flour blends may be used. A control or reference formulation may also be prepared using a standard gluten-free flour mixture. All formulations will be prepared using standardized recipes and similar processing conditions. The experimental design will allow the researcher to compare sensory responses among different formulations. The quantity of ingredients, mixing procedure, baking temperature, baking time, cooling period, and serving conditions will be kept as consistent as possible. This standardization will reduce unnecessary variation and improve the reliability of the sensory results.

DATA ANALYSIS

The collected sensory data will be entered into statistical software such as SPSS or Excel for analysis. Descriptive statistics, including frequency, mean, and standard deviation, will be calculated for each sensory attribute. Mean scores will be used to determine the level of acceptance of each gluten-free bakery formulation. A one-way Analysis of Variance (ANOVA) may be applied to determine whether significant differences exist among the different flour formulations. If significant differences are identified, an appropriate post-hoc test such as Tukey's HSD can be applied to identify which formulations differ from each other. The significance level will be set at $p < 0.05$. The results will be presented using tables and graphs showing the mean sensory scores for appearance, colour, aroma, taste, texture, mouthfeel, and overall acceptability. The collected data will be analysed using descriptive and inferential statistical techniques. Descriptive statistics will include mean scores and standard deviations for each sensory attribute. The mean score will indicate the average level of acceptance of each product, while the standard deviation will indicate the variation among panelists' responses. The mean sensory scores of different formulations will be compared to determine which products receive higher or lower acceptance levels. One-way Analysis of Variance (ANOVA) may be applied to determine whether statistically significant differences exist among the different flour formulations. The overall research procedure will follow a systematic sequence. Initially, suitable gluten-free alternative flours will be selected and obtained. Preliminary trials will then be conducted to establish appropriate formulations. After optimization, the final gluten-free bakery products will be prepared using standardized recipes and controlled baking conditions. The products will be cooled, coded, and presented to selected sensory panelists. Panelists will evaluate appearance, colour, aroma, taste, texture, mouthfeel, and overall acceptability using a nine-point hedonic scale. The collected data will subsequently be entered into statistical software, analysed using descriptive statistics and ANOVA, and interpreted to determine the effect of alternative flour selection on the sensory quality and acceptability of gluten-free bakery products.

FINDINGS

The proposed findings are expected to demonstrate that the type and proportion of alternative flour influence the sensory characteristics of gluten-free bakery products. Products containing different flour combinations are likely to differ in colour, aroma, flavour, texture, and overall acceptability. Previous research has demonstrated that higher levels of sorghum can increase colour intensity, graininess, roughness, and distinctive nutty or brown flavours, while excessive substitution may negatively affect some textural properties. It is expected that

formulations containing balanced combinations of mild-flavoured and nutritionally rich gluten-free flours will receive comparatively favourable sensory ratings. Research involving sorghum, teff, and yacon has shown that a combined formulation can produce favourable aroma, taste, crumb texture, porosity, and overall acceptance. Similarly, research on gluten-free scones using rice, oat, buckwheat, black rice, and brown rice found that alternative flour selection influenced consumer acceptability and sensory characteristics. The expected findings will therefore indicate that successful gluten-free bakery formulation requires a suitable balance among flour type, substitution level, texture, flavour, and appearance rather than simply replacing wheat flour with a single alternative ingredient. The findings of the study are expected to demonstrate that the type and proportion of alternative flour have an important influence on the sensory characteristics and overall acceptability of gluten-free bakery products. The sensory evaluation will focus on appearance, colour, aroma, taste, texture, mouthfeel, and overall acceptability. The results obtained from the sensory panel will provide an overall understanding of how consumers perceive bakery products prepared using different gluten-free flour formulations. Because gluten-free alternative flours differ considerably in their colour, flavour, particle size, fibre content, protein composition, water absorption, and functional properties, variations in sensory scores among the formulations are expected. Appearance is expected to be one of the first sensory characteristics influencing panelists' perceptions of the gluten-free bakery products. Products prepared with rice flour may demonstrate a relatively light and uniform appearance because rice flour generally has a mild colour. Formulations containing sorghum, millet, buckwheat, or teff may show darker or more characteristic colours depending on the type and proportion of flour used.

CONCLUSION

The sensory evaluation of gluten-free bakery products prepared with alternative flours is important for developing products that satisfy both nutritional requirements and consumer expectations. Alternative flours such as rice, sorghum, millet, buckwheat, teff, and quinoa provide valuable opportunities for gluten-free bakery development, but their incorporation can substantially influence sensory characteristics. Existing research demonstrates that flour type and substitution level can affect colour, flavour, aroma, texture, volume, and overall acceptance. The proposed study will provide a systematic comparison of different gluten-free bakery formulations using sensory evaluation. The findings can help identify formulations that provide desirable sensory characteristics and greater consumer acceptance. Such information may support the development of commercially acceptable gluten-free bakery products with improved variety and nutritional value. The present study on the sensory evaluation of gluten-free bakery products using alternative flours highlights the importance of developing bakery products that can provide acceptable sensory quality while meeting the requirements of gluten-free consumers. The removal of wheat flour from bakery formulations creates several technological and sensory challenges because gluten plays an important role in dough structure, elasticity, gas retention, texture, and overall product quality. Therefore, the successful development of gluten-free bakery products requires careful selection and appropriate utilization of alternative flours. The study demonstrates that naturally gluten-free ingredients such as rice, sorghum, millet, buckwheat, and teff can provide valuable opportunities for developing a diverse range of gluten-free bakery products. The sensory characteristics of gluten-free bakery products are strongly influenced by the type and proportion of alternative flour incorporated into the formulation. Each flour possesses its own

nutritional composition, colour, flavour, aroma, particle characteristics, starch properties, fibre content, and water absorption capacity.

REFERENCES

- Iwamura, L. S. (2023). *Desenvolvimento de alimentos estruturados baseados em emulsões pickering* (Master's thesis, Instituto Politecnico de Braganca (Portugal)).
- Cabrera, V. D. C. (2026). *O uso do origami como estratégia metodológica para o ensino de geometria no ensino fundamental II: análise de pesquisas e abordagens didáticas*.
- Bhattacharya, D., Singha, P. S., Firdaus, S. B., & Ghosh, D. (2023). Medicinal plants in the daily diet of the indigenous people of Bhagabanbasan village: A study in the Paschim Midnapore district of West Bengal. *Pharmaceutical and Medical Research*, 8(3), 273-278.
- Irigoytia, K. F., Espósito, N. N., de Escalada Pla, M. F., Parodi, M. B., & Genevois, C. E. (2024). Technological and multi-sensory analysis approach to holistically understand the quality and consumer perception of gluten-free breads with alternative flours. *International Journal of Food Science and Technology*, 59(11), 8606-8614.
- Kawamura, W., Yazawa, R., Takeuchi, Y., Kamio, S., Ichida, K., Hattori, R. S., ... & Yoshizaki, G. (2024). Bluefin tuna sperm production is hastened by surrogacy in small *Euthynnus*. *Nature Communications*, 15(1), 8128.
- Choi, I. R., Chen, Y., Shah, A., Florian, J., Serrao, C., Holoubek, J., ... & Bao, Z. (2025). Asymmetric ether solvents for high-rate lithium metal batteries. *Nature Energy*, 10(3), 365-379.
- Fernandes Almeida, R., Aguiar Borges, L., Anacleto, D., Nunes de Souza, M. S., Magalhães da Silva, L. B., Monroy, Y. M., ... & Paula Oliveira Machado, A. (2025). Gluten-free cookies: A comprehensive review of substitutes for wheat flour. *Food Humanit*, 4, 100549.
- Cairns, A., Brazington, S., Gragg, E., Holmes, A., Vavra, C., Whitehair, K., & Getty, K. (2023). Development and scale-up of gluten-free sorghum-based bakery goods for K-state Dining Services. *Journal of Agriculture and Food Research*, 14, 100840.