ISSN: 3640 – 3748
Volume 10, Number 2, 2025
International Journal Research in Home Economics

SENSORY ANALYSES OF CORN-SOYA GRITS MEAL FOR OPTIMAL UTILIZATION, CONSUMERISM OF SOYA BEANS AND SUSTAINABILITY OF ADEQUATE FAMILY DIET AMID SOCIAL- ECONOMIC CHALLENGES

Obiana, Uche Viola and Jackson Vala
Department of Home Science and Management,
Federal University Gashua. Yobe State, Nigeria

Email: ucheviola15@gmail. com

ABSTRACT

This research explored the acceptability of maize-soya grits meal pottage, emphasizing its optimal nutritional balance and affordability. The study aimed to provide insights into the potential nutritional benefits and cost-effectiveness of incorporating soya bean grits into maize grits meals. These insights are crucial for families looking to make informed dietary choices during economically challenging times. Sensory evaluations, assessing factors such as taste, texture, and aroma, were conducted with semi-trained panelists from the Faculty of Agriculture at the Federal University of Gashua, Yobe State. The results indicate that maize-soya grits meal pottage, created from a blend of legumes and cereal grits, not only enhances the meal's nutritional value but also improves its taste. This study holds significant implications for family nutrition, efficient use of soya beans, and the sustainability of a well-balanced family diet amid economic hardships.

Keywords: Maize Grits: Soybean Grits: Legumes Gwate (Maize Meal): Saturated Fat

INTRODUCTION

Food has historically served as a cornerstone of life, creativity, and cultural heritage (Pollan 2008; Montanari, 2013). It has the unique ability to evoke emotions and connect people across cultures, acting as a universal language that bridges divides in geography, generation, and socio-economic status. However, as food systems face unprecedented challenges, the importance of meal adaptation for healthy living becomes increasingly clear (FAO 2020). The dish known as "Gwate" (maize meal), also referred to as Pate' or Tere' locally, is commonly consumed in Northern Nigeria. It is particularly favored by the Berom people and is a staple food in Central Plateau and Southern Kaduna. Made primarily from corn grit and prepared with various vegetables, *Gwate* is a semi-solid porridge traditionally served in calabashes with local spoons. While it can also be made using other cereals like fonio and millet, maize remains a key ingredient due to its rich carbohydrate and protein content, as well as vitamins (Emebu *et al.* 2011; Madukorshi *et al*., 2009). Recently, the focus on *Gwate* has increased, especially among low-income households in urban areas and rural regions, making it a significant dietary option for adults and a primary weaning food for children. However, much traditional porridges are primarily starch-based, often lacking in essential nutritional requirements. This has prompted the inclusion of legumes and root vegetables to enhance their nutritional profile. Corn (*Zea mays*), cultivated annually worldwide, is a vital source of carbohydrates and a staple in many Nigerian diets, serving both as food and as feed in industries (Hidayah *et al*. 2019). Corn is primarily composed of starch, with increasing demand driving up prices amid economic challenges. The corn kernel is nutritious, containing protein, lipids, carbohydrates, and traces minerals, but lacks some essential amino acids. Integrating legumes like soya beans can significantly improve the nutritional profile of corn meals (Mensa-Wilmot *et al*., 2001). Soybean (Glycine max) is a crucial crop with significant economic and social impact globally, providing a substantial portion of animal protein and playing key roles in various industries. In Nigeria, despite its abundance, soybeans are underutilized in households, mainly being fed to cattle. This creates an opportunity to develop a nutritionally balanced meal by

combining corn and soy grits, addressing food shortages and supporting healthy family diets (Thompson *et al*., 2010). Soybeans are rich in omega-3 fatty acids, protein, and essential minerals, making them a versatile ingredient in many food products. The low saturated fat and cholesterol content of soy products, such as soy milk and tofu, make them appealing for various dietary needs (Kesenkaş *et al*., 2011; Kesenkaş *et al*., 2013)

Nutritional and Health Benefits of Soybeans

Soybean oil is particularly noted for its high content of essential unsaturated fatty acids crucial for human health, including α-linolenic acid (omega-3), linoleic, gamma-linolenic acid, and arachidonic acid (omega-6), and oleic acid (omega-9) (Ecocrop, 2012, Wyk, 2005). Research indicates that soybean oil plays a beneficial role in managing and preventing diabetes by improving insulin sensitivity and exerting anti-obesity effects (Nikolic *et al*., 2009, Olguin *et al*., 2003. It has also been shown that a small quantity of soybean oil, rich in linoleic and alpha-linolenic acids, can enhance diabetic characteristics and restore desaturase levels (Coll *et al*., 2008). Moreover, omega-3 fatty acids present in soybean oil are linked to a decreased risk of cardiovascular diseases, reduced triglycerides, and possess anti-thrombotic, anti-inflammatory, and antihypertensive properties (Leikin Frenkel *et al*., 2004; Sudheendran *et al*.. 2010).

Statement of the study

In many northern regions, 'Gwate' (corn meal) serves as a staple food but is deficient in omega-3 fatty acids. A lack of these fatty acids can lead to various health issues, including impaired brain development, cardiovascular problems, inflammation, and poor wound healing—concerns prevalent in numerous Nigerian households (Sudheendran *et al*., 2010). While more expensive seafood options like sardines and salmon are excellent sources of omega-3 fatty acids, they are often unaffordable for lower-income families. Plant sources such as soybean oil and walnuts can provide alternative omega-3 options. Nutritionally, traditional maize meal lacks sufficient protein, which, combined with economic difficulties, limits families from achieving a balanced diet (Sudheendran *et al*., 2010). The nutritional profile of a corn-soy composite meal needs to be better understood to assess its adequacy and acceptability in fulfilling dietary needs. Additionally, soybeans remain underutilized, with their potential applications not fully explored, leaving their demand focused primarily on producing awara (bean cake) and tom-brown (a flour mix). This limited uptake keeps prices low, with one 2.5 kg 'mudu' of soybeans costing approximately #2000, whereas other legumes can cost around #6000.

Objectives of the Study

The overarching goal of this study was to analyze the sensory properties and nutritional content of Gwate meals enriched with soy grits and oil. Specific objectives include:

1. Formulating a cereal-based meal incorporating soybean grits and oil.
2. Analyzing the nutritional composition of the enriched Gwate.
3. Assessing the acceptability of the fortified Gwate meals using a 9-point hedonic scale.

Significance of the Study

This research offers crucial insights for addressing nutritional deficiencies across various socio-economic backgrounds amid national hunger challenges. It could serve as a nutritious option for weaning children and an easy-to-eat meal for the elderly. Furthermore, this meal might support individuals with lactose intolerance or those with specific health conditions. Due to a lack of information on Gwate's recipe adaptations and consumer preferences, this study provides a foundation for future inquiries into optimizing soybean usage in family meals and food industries.

Scope of the Study
The study focuses on creating corn meals (Gwate) using a mixture of corn-soy grits and oil, promoting dietary fortification, particularly among the families, staff, and students at the Federal University Gashua, Yobe State, Nigeria.

Research Questions
To tackle the issue of economic constraints in providing adequate meals, the following questions were posed:
What are the chemical properties of corn meal (Gwate) composed of corn-soy grits and oil?
What is the level of acceptability of the newly developed diets as assessed by the 9-point hedonic scale?

MATERIALS AND METHODS
Research Design
This study employed an experimental research design integrating both qualitative and quantitative methods. The quantitative aspect comprised laboratory work involving the selection and preparation of ingredients for Gwate, while qualitative data were gathered from panel feedback.

Sample/Material Collection
Ingredients like corn grit, soybean oil, soybeans, palm oil, tomatoes, peppers, onions, locust beans, spinach, and cabbage were sourced from Gashua market. Equipment used included bowls, spoons, cooking pots, knives, baskets, and chopping boards.

Preparation Procedure
Three kilograms of corn grits and one kg of soybeans were procured. The soybeans were rinsed, soaked for 24 hours, cooked, sundried, and milled to produce a coarse texture. The preparation of Gwate involved washing and preparing all ingredients, cooking brisket bone and meat, incorporating palm and soy oil, and blending in the ingredients before serving.

Recipe preparation method
Ingredients ;Onions 6 L, Hot bonnet 10 Pcs, Tomatoes paste 50 g, Sorrel leave 30g, Cabbage 60g, Spinach 150g, Locust beans 5g, Corn grit 625g, Brisket bone 2kg, Palm oil 228 g, Seasoning 6 cubes of knor, Salts 3g, Water 2500g

Samples Code and Ratio Formulation
CG1 = 625g of CG at 100% was the control
CSG 2 = 525g of CG at 90% ; and 62.5g of soy grits (SG) at 10% ratio.
CSG 3 = 500g CG at 80%; 125g of soy grits at 20% ratio
CSG4 = 437.5g CG at 70%; 187.5of soy grits at 30% ratio
CSG5 = 375g CG at 60%; 250g of soy grits at 40% ratio
CSG6 = 312.5g CG at 50%; 312,5g of soy grits at 50% ratio

Method of preparation of Maize meal "Gwate" (control and adapted)
Wash and Prepare all the ingredients used for cooking. i.e Corn grit, vegetables and keep aside.
Put the washed meat and brisket bone in the pot and season with onions, seasonings (cubes of Maggi and salt). Put on the fire flame from the cooker and add 2500g of water and allow simmering for 15-20minutes until it can be crush.
Put another sauce pan on the fire, add the palm oil I the control ample 100% corn grits and soya oil in the other five samples (2-6).

Add onions and Tomato pepper mix and stew for 5minns. Add other ingredients such as the locust beans and seasoning allow stewing for 10-15minutes
Add maize grit - soy grit, stirring vigorously and quickly to prevent lumps.
Allow to cook for 10-15minutes to cook when grains turn soft is a clear indication that it is cooked.
Add "Yakuwa" (sorrel leaves) and washed spinach and allow to simmer for 2-3 minutes bring down and serve as main dish for breakfast, lunch or supper .

Sensory Evaluation
Cooked samples were presented to 60 panelists for evaluation of acceptability based on appearance, taste, aroma, texture, and overall preference using a 9-point hedonic scale.

Data Collection Procedures
Coded samples of cooked corn-soy grits were given to the panelists, who provided feedback using hedonic assessment sheets analyzing various sensory qualities.

Data Analysis Techniques
Sensory evaluation results were processed statistically using descriptive percentages and ANOVA to identify differences among sample treatments. Proximate composition of Gwate samples was determined following AOAC (2005) methodologies at Yobe State University's laboratory, focusing on carbohydrates, proteins, fats, and ash content.

RESULTS AND DISCUSSION
Table 1: Sensory Analysis (Population and sample size 80)

Sample code	Taste	Colour	Aroma	Texture	General acceptability
CGM1	7.35±0.88^{a}	7.76±1.64^{a}	7.62±2.28^{a}	7.67±3.02^{b}	7.47±1.81^{a}
CSGM2	7.58±1.46^{bc}	8.10±0.86^{a}	7.64±1.33^{a}	7.74±1.72^{a}	7.20±2.09^{a}
CSGM3	7.67±0.79^{ab}	7.84±1.10^{a}	7.88±0.88^{a}	7.76±1.47^{a}	7.53±1.60^{a}
CSGM4	7.91±1.20^{bc}	8.03±1.23^{a}	7.89±1.59^{a}	7.77±1.58^{a}	7.67±1.89^{a}
CSGM5	7.74±1.61^{c}	8.03±1.15^{a}	7.75±1.71^{a}	7.78±1.40^{a}	7.47±2.02^{a}
CSGM5	7.74±1.61^{c}	8.03±1.15^{a}	7.75±1.71^{a}	7.78±1.40^{a}	7.47±2.02^{a}
CSGM6	7.70±0.78^{ab}	8.02±0.76^{a}	7.50±2.10^{a}	7.80±1.38^{a}	7.50±1.90^{a}

Mean along the same subscript are not significantly different (p = 0.05)
These values are the 9-point Hedonic scale of response to each attribute. The Hedonic scales are: Key: 1 = Dislike extremely, 2 = Dislike very much, 3 = Dislike moderately, 4 = Dislike slightly, 5 = Neither like nor dislike, 6 = Like slightly, 7 = Like moderately, 8 = Like very much and 9 = Like extremely. Values in the same row with same superscripts are not significant different at 0.05 level of probability.

Table 1 displays the sensory evaluation outcomes for six samples (CGM1, CSGM2, CSGM3, CSGM4, CSGM5, CSGM6) assessed on five characteristics: Taste, Color, Aroma, Texture, and General Acceptability. The scores presented are the mean values ± standard deviation, with letters (a, b, c) denoting significant differences among the samples.

Taste
Samples CSGM4 (70:30% ratio) and CSGM5 (60:40% ratio) received notably higher mean scores of 7.91 and 7.74, respectively, indicating a preference over CSGM2 and CSGM3. This suggests that a moderate incorporation of soy grits enhances the flavor of the dish. Conversely, CGM1, which consists entirely of corn grits, was ranked the least preferred, reinforcing the positive influence of adding soy grits on taste.

Color
Sample CSGM2, with an 80:20% corn-to-soy grit ratio, was the most favored, achieving a significantly higher mean color score than CGM1, CSGM3, CSGM4, CSGM5, and CSGM6. However, differences in color scores across all samples were not statistically significant.

Aroma
The aroma did not serve as a significant differentiator among the samples, suggesting no notable differences based on the data in Table 1. Nonetheless, CSGM4 (70:30%) and CSGM3 (60:40%) were the most preferred, with mean scores of 7.89 and 7.88, likely attributable to the balanced soy grit ratio.

Texture
Sample CSGM6, which features a 50:50% corn-to-soy grit ratio, was most favored for texture with a mean score of 7.80 but did not significantly differ from CSGM5, 4, 3, and 2, indicating similar textures. This suggests that incorporating soy grits improves meal texture, with better texture observed at higher soy grit ratios. CGM1, containing solely corn grits, was least preferred for texture, highlighting the notable impact of soy grits blends.

General Acceptability
Overall acceptability was fairly consistent across samples, except for CSGM2, which had a mean score of 7.20, indicating it was least preferred. The highest-rated sample for general acceptability was CSGM4 with a score of 7.67; however, this was not significantly different from other samples. This indicates that adding a 70:30% corn-to-soy grit ratio yields a more favored taste and aroma, although it does not necessarily enhance nutritional composition. The least accepted sample was CSGM2 (90:10 ratio) at 7.20.
In summary, samples CSGM4 and CSGM5 were favored for taste, CSGM2 for color, while CGM1 requires improvement in texture. These findings suggest that soy grits at various inclusion levels are preferred over the regular 100% corn grits meal.

Table 2: Proximate Analysis (%) of samples (g/100g)

Sample	Carbohydrate	Ash	Crude protein	Crude fat	Moisture
CGM1	65.30±1.2^{a}	1.47±0.21^{a}	10.06±2.78^{a}	11.34±0.89^{a}	11.13±1.2^{a}
CSGM2	63.28±0.59^{a}	1.13±0.02^{a}	12.02±1.98^{a}	12.43±1.19^{a}	10.24±0.20^{ab}
CSGM3	61.32±1.05^{a}	1.09±0.1^{a}	15.94±5.67^{a}	12.32±0.48^{a}	9.96±0.47^{ab}
CSGM4	56.34±1.02^{b}	1.13±0.2^{a}	19.58±1.52^{a}	13.09±0.55^{a}	9.74±0.05^{ab}
CSGM5	55.69±0.99^{b}	0.95±0.5^{a}	21.35±0.14^{ab}	13.26±0.61^{a}	9.13±0.05^{ab}
CSGM6	53.08±1.01^{b}	0.73±0.02^{a}	23.55±1.97^{a}	13.53±0.35^{a}	9.10±0.36^{b}

Means along the same subscripts are not significantly different (p<=0.05).
Key: CGM1=100% corn grits meal (control); CSGM2=90%corn:10% soy grits, CSGM3,=80 corn grits;20% soy grits, CSGM4=70 corn grits:30% soy grits, CSGM5=60 corn grits, :40% soy grits, CSGM6=60 soy grits: 40% corn grits ;
Discussion on Proximate

Carbohydrate Content
Sample CSGM6 held the lowest carbohydrate content at 53.08%. The carbohydrate content in samples CSGM2-6 decreases proportionally with the addition of soy grits. Nonetheless, no

statistical differentiation was observed between the carbohydrate reductions in samples CGM1, 2, and 3, nor among CSGM4, 5, and 6.

Moisture Content
Moisture content varied from 11.13% to 9.10%, with CSGM1 and CSGM2 exhibiting significantly higher moisture levels compared to others. Samples CSGM3 through CSGM6 had similar lower moisture levels (around 9% and below) than CGM1 and CSGM2.

Ash Content
All samples exhibited low ash content, ranging from 0.09% to 1.47%. CGM1 held the highest ash content (1.47%) while CSGM6 had the lowest (0.73%). These differences were not statistically significant.

Crude Protein
Sample CSGM3 had a significantly higher crude protein level (23.55%) compared to the other samples. Other samples showed similar protein contents ranging from 10.06% to 21.3%, with sample CSGM6 (50:50 ratio) presenting the highest at 23.55%, while CGM1 had the lowest at 10.06%. Overall, these results imply that CSGM6 has a distinctive nutritional profile with high protein and lower moisture content.

Crude Fat
The fat content across all samples was relatively similar, ranging from 11.34% to 13.53%. While the introduction of soy grits appeared to influence fat content, these differences were not statistically significant, although further analysis may identify the parameters for omega-3 fatty acids.

Table 3: Linearity and estimated regression parameters for OMEGA-3 Fatty acid

Fatty Acids	Gwate (100%) Corn grit Meal	Gwate (90:10 Corn -soy grit Meal)	Gwate(80:20 Corn -soy grit Meal)	Gwate(70:30 Corn -soy grit Meal)	Gwate(60:40 Corn -soy grit Meal)	Gwate(50:50 Corn -soy grit Meal)
C4	1.01±0.05[a]	1.03±0.2[a]	1.11±0.1[a]	1.15±0.99[a]	1.16±.01[a]	1.22±0.1[a]
C6	1.40±0.1[a]	1.40±0.5[a]	1.24±0.05[a]	1.21±0.60[a]	1.40±0.02[a]	1.35±0.12[a]
C8	1.33±0.09[a]	1.02±1.0[a]	1.09±0.1[a]	1.15±1.0[a]	1.02±1.1[a]	1.12±0.32[a]
C10	1.35±0.49[a]	1.35±0.1[a]	1.36±0.1[a]	1.39±0.32[a]	1.40±0.54[a]	1.41±0.27[a]
C11	1.34±0.02[a]	1.34±0.1[a]	1.32±0.29[a]	1.32±0.2[a]	1.34±0.08[a]	1.33±0.15[a]
C18:3n3		0.23±0.03[b]	1.012±0.1[a]	1.02±0.31[a]	1.06±0.4[a]	1.08±0.3[a]

C4=Butyric acid, C10=caproic acid, C6:capric acid, C11:undecanoic acid, C8=caprilic acid.c18: 3n3= Alpha-linolenic acid. omega-3 fatty acid

Discussion on Fatty Acids
Samples with higher soy grit ratios (70:30, 60:40, and 50:50) generally showed better nutrient content, suggesting that adding soy grit enhances nutritional value. The presence of C18:3n3 (Alpha-linolenic acid) was significantly higher in samples with soy grit compared to the 100% corn meal, which entirely lacked this omega-3 fatty acid. Incorporating soy grit into corn meal improves its nutritional profile, particularly regarding fatty acid composition, which is vital for health and helps reduce cardiovascular disease risks.

Table 3: Elemental Analysis

Sample	P	Ca	K	Mg	Fe
Gwate (100% Corn	96.75±2.08[a]	35.00±0.5[a]	122.50±1.5[ab]	9.20±1.1[a]	1.15±.051[a]
Gwate (90:10 Corn-soy grit)	95.50±1.5[a]	33.50±0.5[a]	125.30±1.5[a]	9.50±1.00[a]	1.05±0.1[a]
Gwate (80:20 Corn-soy grit)	89.22±2.29[bc]	35.20±2.1[a]	120.20±1.2[b]	9.35±1.5[a]	1.05±0.51[a]
Gwate (70:30 Corn-soy grit	85.50±1.5[c]	27.8±1.43[b]	122.5±3.01[ab]	10.00±2.0[a]	1.26±0.11[a]
Gwate (60:40 Corn- soy grits					
Gwate (60:40 Corn-soy grit)	92.2±1.17[b]	32.50±1.5[a]	120.25±0.75[b]	9.75±1.8[a]	1.20±0.2[a]

P= phosphorus, CA = calcium, K = potassium, Mg = magnesium, Fe = iron

Discussion on Minerals

Adding soy grits to corn meals influences mineral content, with varying effects based on the ratio. The 100% corn meal had a higher mineral content, while the 90:10 corn-to-soy ratio maintained a balanced mineral profile. With increased soy grit ratios (80:20, 70:30, 60:40, and 50:50), phosphorus and calcium levels dropped, potentially due to dilution, although the 70:30 ratio indicated greater iron content, suggesting that soy grit could be a beneficial iron source.

Regular corn grits meal lacks sufficient nutrient density to meet dietary needs. Thus, enriching "gwate" with cost-effective soy grits is crucial for creating nutritionally dense, palatable food options. This study investigated developing nutrient-rich and acceptable food products through corn-soy grits and soy oil blends, resulting in six formulations. Sensory data revealed that 90:10 and 80:20 corn-soy composites were more favored by panelists than other ratios.

CONCLUSION

This study offered insights into the nutritional and sensory characteristics of corn meal made with soy grits and oil blends, showcasing that maize-soy blends provide a rich source of essential macronutrients and micronutrients, as well as overall enhanced acceptability compared to conventional corn grits meals. Understanding these nutritional and sensory aspects could help address food security in Nigeria, especially during challenging times. Educational initiatives on nutrition and meal adaptation using legumes like soybeans could significantly benefit families by enhancing dietary quality.

RECOMMENDATIONS

1. Implement nutritional education programs to raise awareness of the benefits of soybeans and their derivatives, empowering families to maximize the nutritional and economic advantages for sustained health.
2. Educate Nigerian families on practical meal adaptation techniques, especially regarding legumes, to meet dietary needs amid socio-economic challenges.
3. Conduct further research into the acceptability of incorporating processed soy varieties into various cultural diets across Nigeria.

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