International Journal of Engineering, Management and Humanities (IJEMH)
Volume 6, Issue 3, May-June, 2025 pp: 55-60 ISSN: 2584-2145 www.ijemh.com

Development and Evaluation of Foxtail Millet and Jowar Basedmuffins

B. ROHITHA[*1], Dr. A. Swaroopa Rani [1], G. VikramGoud [2]

1. Student,Department of Food Technology, Oil Technology & Pharmaceutical Research Institute, J N T University, Ananthapuramu-515001, Andhra Pradesh- India.*

1. Professor, Head & Chairman- Board of Studies, Department of food technology, Oil Technological & pharmaceutical Research Institute, J.N.T University, Ananthapuramu-515001, Andhra Pradesh-India.

2.G. VikramGoud, Regional manager quality assurance, The akshayapatra foundation, Hyderabad.

**Corresponding Author*

Date of Submission: 07-05-2025 Date of Acceptance: 17-05-2025

ABSTRACT: This study presents the development of a functional, nutritious muffin formulated using foxtail millet and jowar (sorghum) flours as gluten-free, health-promoting alternatives to refined wheat flour. These ancient grains are rich in dietary fibres, plant-based proteins, iron, magnesium, and complex carbohydrates cateringhealth-consciousindividuals and those with gluten intolerance. Foxtail millet provides a low glycaemic index and supports digestive health, while jowar offers antioxidant benefits and heart health support. Brown sugar replaces refined sugar to enhance sweetness naturally while retaining trace minerals. Banana is utilized for natural sweetness, moisture, potassium, and binding capacity, eliminating the need for synthetic stabilizers. Milk and butter contribute to improved texture, flavour, and nutritional value, while cardamom powder imparts aroma and digestive benefits. Baking powder is used for leavening to produce a soft, fluffy texture. Various combinations of millet flours and banana will be evaluated through sensory trials. This innovation aims to produce a sustainable, wholesome muffin aligned with functional food trends and clean-label preferences.

KEYWORDS: Foxtail millet, jowar, muffins, gluten-free, functional food, nutritious, natural sweetener, plant-based, banana, dietary fiber.

I. INTRODUCTION:

Muffins are a popular category of baked goods that combine convenience, versatility, and indulgence, making them a staple in both home kitchens and commercial bakeries around the world. Traditionally classified as a type of quick bread, muffins are prepared using chemical leavening agents like baking powder or baking soda, which allow for rapid preparation without the need for fermentation. They are typically characterized by their soft, moist crumb and slightly domed top, available in a wide array of sweet and savory varieties. Muffins can be enriched with fruits, nuts,

MUFFINS:

spices, chocolate, or even vegetables, offering endless customization based on consumer preference. Over time, muffins have evolved from simple breakfast items to nutrient-enriched snacks that can serve as meal replacements or functional food products. With growing awareness of health and wellness, modern muffin formulations increasingly incorporate whole grains, plant-based ingredients, and reduced sugar or fat content to align with dietary trends and nutritional guidelines. This adaptability has cemented muffins as not only a comfort food but also a dynamic platform for nutritional innovation and culinary creativity.

In the evolving landscape of functional foods and health-oriented bakery products, the integration of traditional grains with modern formulations represents a transformative approach to nutrition and taste. The development of foxtail millet and jowar-based muffins marks a unique innovation, blending the ancient nutritional wisdom of millets with contemporary consumer preferences for indulgent yet wholesome baked goods. This novel product draws from a rich palette of ingredients—foxtail millet and jowar for their high fiber and micronutrient density; ripe bananas for natural sweetness and moisture; milk for its protein and creaminess; brown sugar for a subtle caramel

International Journal of Engineering, Management and Humanities (IJEMH)
Volume 6, Issue 3, May-June, 2025 pp: 55-60 ISSN: 2584-2145 www.ijemh.com

note; butter for its richness; baking powder for leavening; and chocolate for a sensory twist that elevates appeal.

This muffin formulation addresses the growing demand for gluten-free, low-glycaemic, and nutritionally enriched snacks, offering a guilt-free indulgence suitable for a wide range of consumers. By reimagining bakery science through the lens of traditional grains and functional inclusions, this product development initiative not only enhances dietary diversity but also champions sustainability, local crop utilization, and innovative health-forward food design.

FOXTAIL MILLET:

Foxtail millet (Setariaitalica) and jowar, also known as sorghum (Sorghum bicolour), are ancient grains that have been cultivated for thousands of years and are now gaining renewed attention for their exceptional nutritional profiles and adaptability to diverse climatic conditions. Traditionally grown in arid and semi-arid regions, these millets are known for their resilience, requiring minimal water and inputs, making them sustainable alternatives to conventional cereals like wheat and rice. Foxtail millet is rich in dietary fiber, iron, and B-complex vitamins, and is particularly valued for its low glycaemic index, making it suitable for diabetic and weight-conscious individuals.

JOWAR MILLET:

Jowar, on the other hand, is a gluten-free powerhouse packed with antioxidants, phenolic compounds, and essential minerals such as calcium, phosphorus, and magnesium. Both millets offer a well-balanced composition of carbohydrates, proteins, and micronutrients, and are known for promoting digestive health, improving satiety, and reducing the risk of lifestyle-related disorders. With the growing global shift toward functional foods and sustainable agriculture, foxtail millet and jowar have emerged as key ingredients in the development of health-forward and eco-friendly food products.

BANANA:

Banana (Musa spp.) is one of the most widely consumed fruits globally, known for its rich nutritional profile, natural sweetness, and versatility in culinary and industrial applications. Botanically classified as a berry, bananas are a rich source of carbohydrates, particularly natural sugars such as glucose, fructose, and sucrose, making them a quick source of energy. They are abundant in dietary fiber, especially pectin and resistant starch, which help regulate blood sugar levels, improve digestive health, and promote satiety. The high potassium content in bananas plays a key role in maintaining electrolyte balance, supporting heart health, and controlling blood pressure. They also contain significant amounts of vitamin B6, which is essential for protein metabolism and the production of neurotransmitters, as well as vitamin C, which enhances immune function and supports skin health.

Bananas contain antioxidants such as dopamine and catechins, which help reduce oxidative stress and may contribute to a lower risk of degenerative diseases. They are also known for their prebiotic properties, especially in their unripe or green form, where resistant starch acts as a substrate for beneficial gut bacteria, improving overall gastrointestinal function. The magnesium in bananas supports bone health and nerve function, while trace elements like copper and manganese assist in enzymatic functions and antioxidant defences.

II. AIMS AND OBJECTIVES :

AIM:

The aim of this study is to formulate a nutritious and fiber-rich muffin using foxtail millet, jowar, and banana, and to compare its nutritional, sensory, and functional properties with those of conventional muffins made with refined flour.

OBJECTIVES:

1. To develop different formulations of muffins using foxtail millet and jowar flour in combination with banana as a natural sweetener and binder.
2. To assess the effect of baking powder, brown sugar, butter, and milk on the texture, volume, and sensory characteristics of the muffins.
3. To evaluate the nutritional and health benefits of incorporating foxtail millet and jowar, particularly in terms of fiber, protein, and mineral content.
4. To determine the proximate composition (moisture, protein, fat, carbohydrate, ash, fiber) of the developed muffins.
5. To analyse the physico-chemical properties of the muffin such as volume, weight, pH, and moisture retention.
6. To conduct sensory evaluation to assess consumer acceptability based on parameters like appearance, texture, taste, aroma, and overall liking.
7. To evaluate the shelf-life and microbial stability of the muffins over a storage period

International Journal of Engineering, Management and Humanities (IJEMH)
Volume 6, Issue 3, May-June, 2025 pp: 55-60 ISSN: 2584-2145 www.ijemh.com

III. MATERIALS AND METHODS:

RAW MATERIALS:

The raw materials required for the preparation of the product;i.e.
Foxtail millet Flour, Jowar Millet Flour ,Banana ,Brown Sugar,Butter,Milk ,Baking powder, salt.

PREPARATION OF FOXTAIL MILLET FLOUR:

Foxtail millet, a small-seeded and nutrient-rich grain, is commonly used in traditional and health-oriented recipes. To prepare foxtail millet flour, begin by selecting clean, good-quality millet grains free from impurities. Thorough cleaning is essential to remove dust, stones, or foreign matter. Once cleaned, the grains can be lightly roasted in a thick-bottomed pan over medium heat. Roasting not only enhances the flavour but also improves the digestibility and shelf life of the flour. Stir the grains continuously during roasting to ensure even heating and avoid burning. Once they emit a pleasant, nutty aroma and slightly change colour, allow them to cool completely. After cooling, grind the roasted foxtail millet into a fine flour using a suitable grinder or flour mill, and then sieve to obtain a smooth, consistent texture.

PREPARATION OF JOWAR MILLET FLOUR:

The preparation of jowar (sorghum) flour from roasted grains involves a series of steps aimed at enhancing its nutritional quality, flavour, and shelf life. The process begins with the selection of clean, mature, and impurity-free jowar grains. These grains are first dry-cleaned to remove dust and debris, then thoroughly washed under running water to eliminate any remaining contaminants. After washing, the grains are drained and dried either under the sun or in shade until the surface moisture evaporates. Once dried, the jowar grains are roasted in a thick-bottomed pan over medium heat for about 8 to 10 minutes, with constant stirring to ensure even roasting and to prevent burning. Roasting not only enhances the nutty aroma and flavour but also reduces anti-nutritional compounds and improves digestibility. After roasting, the grains are allowed to cool completely and then ground into a fine flour using a grinder or flour mill. The flour is sieved to achieve a uniform, smooth texture, and any coarse particles can be re-ground. Before storing, the flour should be cooled to room temperature to prevent moisture buildup. It is best stored in an airtight container in a cool, dry place or refrigerated for extended shelf life. Roasted jowar flour is nutritious, gluten-free, and rich in dietary fiber, making it ideal for various culinary uses including rotis, porridge, and baked goods like muffins and cookies.

FLOW CHART FOR THE PREPARATION OF MUFFINS:

Ingredients selection
↓
Weighing of dry ingredients
(Foxtailflour, jowar
(flour, salt, bakingpowder)
↓
Mixing of wet ingredients
(brown sugar, butter, banana, milk)
↓
Combination of wet and dry ingredients
↓
Addition of seeds and cardamom powder
↓
Baking of muffins 180℃ for 20-25 minutes
↓
Cooling and packaging
↓
Quality control and testing
↓
Final product

Table-1 Formulations:

INGREDIENTS	VARIATION-**1**	**VARIATION-2**	VARIATION-3
Foxtail Flour	52g	**45g**	50g
Jowar Flour	52g	**45g**	50g
Brown Sugar	32g	**28g**	35g
Butter	26g	**20g**	32g
Banana	40g	**52g**	35g
Milk	25g	**37g**	20g
Cardamom	2g	**2g**	2g
Salt	1g	**1g**	1g
Baking Powder	5g	**5g**	5g

International Journal of Engineering, Management and Humanities (IJEMH)
Volume 6, Issue 3, May-June, 2025 pp: 55-60 ISSN: 2584-2145 www.ijemh.com

Chocolate	15g	**15**	20

PREPARATION OF MILLET-BASED MUFFINS:

Muffins are baked confectionery products made from a mixture of flour, sweeteners, leavening agents, fat, and flavourings. In this formulation, foxtail millet flour and jowar flour were used in combination with banana, milk, brown sugar, butter, baking powder, and cardamom powder. During baking, leavening agents help develop the desired volume and porous texture.

Ingredients were selected and weighed accurately, followed by blending to prepare the batter. Ripe banana was mashed and mixed thoroughly with milk, melted butter, and brown sugar to form a uniform wet mixture. In a separate bowl, foxtail millet flour, jowar flour, baking powder, and cardamom powder were mixed to form a dry blend.The dry ingredients were gradually incorporated into the wet mixture with gentle mixing to form a smooth batter. The batter was then poured into greased or paper-lined muffin trays, filling up to ¾th of the volume.The filled trays were placed in a preheated oven and baked at 180°C for 20–25
minutes. After baking, the muffins were cooled to room temperature on a wire rack. Three different variations of muffins were formulated by changing the compositions of foxtail millet flour, jowar flour, and banana.

METHODS:Moisture Content: To measure the accurate amount of water present in the sample. Moisture content is analyzed by the oven drying method at 105℃ for 3hrs (AOAC 2000).
Formula: Moisture = W 2 /W 1 ×100%

Ash content: To measure the minerals present in it. Ash content is analyzed by using muffle furnace at 550℃ for 6hrs (AOAC 2000).
Formula: Ash = W 2 /W 1 ×100%

ph: It is determined by the digital pH meter.

Carbohydrates: the measure of carbohydrates is by using fehling solution performed according to FSSAI manual method.
Formula: Total Carbohydrates (%) = Volume of sample used (ml)×dilution factor×100

Protein: the protein content is determined by kjeldahl method.
Formula: Nitrogen% = (Volume of HCl × Normality of HCl×1.4007)Weight of sample in gm
Protein (%) = Nitrogen (%) × 6.38

fiber: Determined using the method of AOAC (2000).
Formula: Crude fibre = Weight of the fibre [(W2-W1) - (W3-W1)] × 100
Weight of the sample (g).

Table -2Hedonic Scale:

FEELING /OPINION	RATING
Like extremely	9
Like very much	8
Like moderately	7
Like slightly	6
Neither like nor dislike	5
Dislike slightly	4
Dislike moderately	3
Dislike very much	2
Dislike extremely	1

SENSORY ANALYSIS:
Sensory evaluation scores of Development and evaluation of foxtail millet and jowar based muffinsformulations (Control, variation-1, variation-2, and variation-3) based on a 9-point hedonic scale assessing color, taste, appearance,flavor, texture, and overall acceptability.

IV. RESULTS:

As per sensorial analysis variation-2 was optimized among three variations, because variation-2 got highest overall acceptability compared with variations 1 and 3 because of appreciable colour, flavour, taste, texture and appearance. Overall acceptability score of variation-2 was nearer to the control. Results of sensorial analysis were exhibited in table.no: Colour of optimized product (2) got highest score than variations 1 and 3, and nearer to control. Firstly consumer appetizing for food is stimulated or dampened by its colour. It is the visual sensory attribute, it attracts consumer towards the food product.

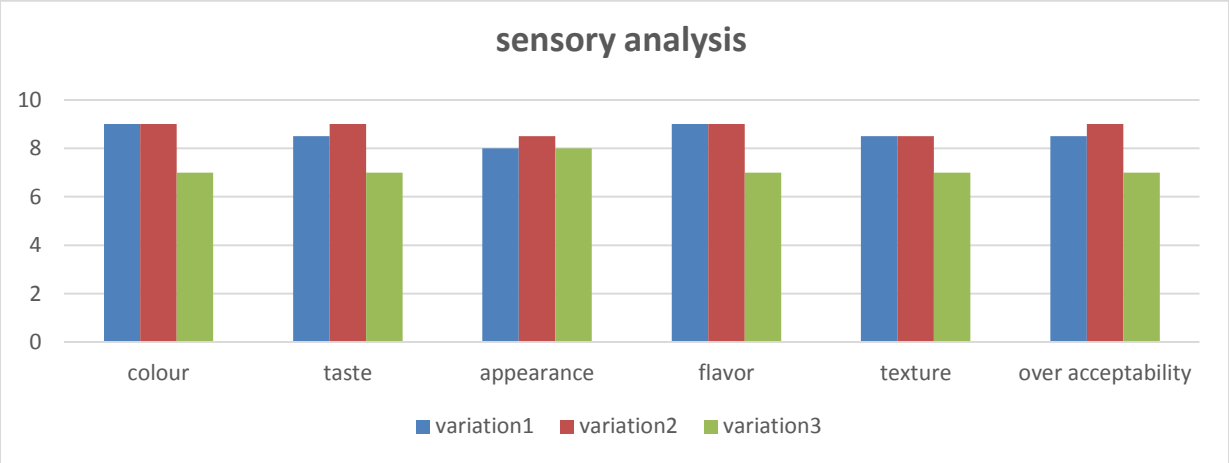
Table-3 Sensory Analysis:

Sensory attributes	Control	Variation-1	**Variation-2**	Variation-3
Colour	9	9	**9**	7
Taste	9	8.5	**9**	7

International Journal of Engineering, Management and Humanities (IJEMH)
Volume 6, Issue 3, May-June, 2025 pp: 55-60 ISSN: 2584-2145 ww.ijemh.com

Appearance	9	8	**8.5**	8
Flavor	9	9	**9**	7
Texture	9	8.5	**9**	7
Overall acceptability	9	8.5	**9**	7

Graphical representation of sensory analysis:



PHYSICO-CHEMICAL ANALYSIS:

The physico-chemical analysis of the developed muffins indicated that the optimized formulation containing foxtail millet and jowar offered improved nutritional qualities compared to the control. The inclusion of these nutrient-rich grains, along with banana and brown sugar, led to increased fiber and protein content. A significant reduction in moisture content was observed in the optimized muffins, contributing to a denser crumb texture and extended shelf life by reducing microbial activity. The muffins also exhibited slightly lower acidity, enhancing flavor and overall palatability. These characteristics helped intensify the natural flavors of millet, banana, and cardamom, ultimately improving consumer satisfaction. The analysis, detailed in Table 4.1, aligns with findings from earlier research, such as Hesham A. Ismail et al. (2020), which support the functional and nutritional benefits of using traditional grains in baked products.

Table -4 Physico-Chemical Analysis:

S.NO	PARAMETERS	CONTROL	SAMPLE	SAMPLE 2	SAMPLE 3
1	Moisture%	25.60	28.10	**21.35**	27.30
2	Fat%	12.20	11.15	**13.50**	15.40
4	Ph	5.65	3.10	**6.10**	8.20
5	Fiber%	1.80	5.30	**4.70**	6.30
6	Protein%	5.80	9.15	**8.90**	9.20
7	Carbohydrate%	53.55	49.50	**50.45**	61.15
8	Ash	0.85	4.20	**1.10**	3.60

V. DISCUSSION:

while also providing calcium and fat-soluble vitamins (such as A and D), which are important for bone health and overall wellness. The use of brown sugar, though still a sweetener, offers a marginal nutritional edge over refined white sugar due to its trace mineral content, including calcium, potassium, and iron, thanks to the retained molasses. Cardamom, while used in small quantities, introduces antioxidant and anti-inflammatory compounds, contributing subtly to the product's functional properties.

From a dietary standpoint, these muffins cater to consumers seeking healthier alternatives to conventional baked goods without compromising on sensory appeal. The higher fiber content supports

digestive health and may contribute to improved satiety, potentially aiding in portion control. The lower glycemic response of whole grains like jowar and foxtail millet makes this product more suitable for individuals managing blood sugar levels, such as those with prediabetes or type 2 diabetes. Additionally, the formulation avoids the use of artificial additives or preservatives, aligning with clean-label trends that are increasingly important in contemporary food markets.

The strategic combination of traditional whole grains, natural sweeteners, dairy, and aromatic spices in these muffins results in a product that successfully integrates taste, texture, and nutritional value. By carefully balancing functional roles, physicochemical properties, and sensory characteristics, this formulation demonstrates a model for the development of bakery products that meet modern consumer demands for health, indulgence, and culinary uniqueness.

VI. CONCLUSION:

Incorporating foxtail millet and jowar into muffin preparation has proven to be a wholesome and innovative approach to modern baking. These ancient grains bring a unique texture and earthy flavor that harmonize beautifully with the sweetness of banana and the richness of ingredients like milk, brown sugar, butter, and cardamom. The use of foxtail millet and jowar not only enhances the nutritional profile of the muffins—offering high fiber, essential amino acids, and vital minerals—but also supports better digestion, improved satiety, and sustained energy release. This fusion of traditional grains with contemporary baking methods results in a product that caters to both health-focused and flavor-conscious consumers. The muffins are soft, moist, and naturally sweetened, providing a guilt-free indulgence suitable for various age groups and dietary needs. Further exploration of different grain ratios, ingredient substitutions, and flavor infusions could open new doors for product diversification and functional bakery innovations. Overall, foxtail millet and jowar-based muffins represent a promising leap in the direction of nutritious, sustainable, and inclusive baking, aligning well with current consumer trends toward health, wellness, and mindful eating.

REFERENCES:

1. Bhatt & Gupta (2019)
Reported that muffins developed with 50% foxtail millet flour and 50% wheat flour exhibited improved crude fiber, iron, and calcium levels while maintaining desirable organoleptic qualities.
2. Kumar et al. (2020)
Found that partial substitution of refined flour with jowar flour (30–50%) resulted in muffins with increased protein and antioxidant activity.
3. Gupta et al. (2019)
Highlighted that muffins prepared with a blend of foxtail millet and jowar flour demonstrated superior mineral content, particularly in terms of iron and zinc.
4. Devi et al. (2014)
Showed that foxtail millet is a promising cereal for managing diabetes and cardiovascular risks due to its low glycemic index and phenolic content.
5. Chiremba et al. (2012)
Recognized jowar for its antioxidant properties and high content of phenolic acids, flavonoids, and dietary fiber, making it a beneficial base ingredient for functional muffins.
6. Mehta & Bansal (2017)
Validated foxtail millet's nutritional benefits, showing that even a 25% substitution could significantly enhance iron and fiber without adversely affecting crumb firmness.
7. Kulkarni &Naik (2012)
Demonstrated that jowar increased iron and calcium levels in baked goods, with acceptable sensory properties up to 30% inclusion.
8. Gorib et al. (2019)
Indicated that millet-based muffins contain a balanced profile of amino acids, supporting body growth and muscle repair, ideal for vegetarian diets.
9. Fernandes&Rathi (2025)
Combined cardamom, chocolate, millet, and banana for high flavor ratings and wide acceptability, showing potential for indulgent yet healthful muffins.
10. Chatterjee & Singh (2023)
Found that a combination of 40% foxtail millet, 30% jowar, and 30% wheat flour offered a good balance between crumb softness and structural integrity.