JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

"Development and Evaluation of Cookies From Germinated Kodo Millet (*Paspalum scrobiculatum*) Flour"

[1]Geetha Shree K & Shekhara Naik R*
[1]Faculty, *Professor and Head
[1]Department of Food Science and Nutrition, Yuvaraja's College, University of Mysore, Mysuru, Karnataka, India

Abstract: Cookies are the universally favoured snack across all age groups. Millets— particularly Kodo millet—have garnered attention due to their rich composition of essential nutrients and health-promoting properties. Kodo millet *(Paspalum scrobiculatum)* is an underutilized grain notable for its high dietary fiber content, low glycemic index, and abundance of minerals such as calcium, phosphorus, iron, and magnesium. These attributes contribute to its potential in managing blood glucose levels and promoting overall health. However, the presence of anti-nutritional factors can hinder nutrient bioavailability, which can be mitigated through processing methods like germination.

This study aimed to develop cookies incorporating germinated Kodo millet flour (GKMF) at substitution levels of 20%, 25%, and 30%, comparing them with a control sample developed entirely of refined wheat flour. The sensory attributes of the cookies were evaluated by a semi- trained panel of 30 members using a 9-point hedonic scale. The formulation that achieved the highest acceptability (V1-80:20) was further analyzed for its nutritional composition storage stability.

The findings revealed that cookies containing GKMF exhibited a significant increase in dietary fiber and mineral content compared to the control. Cookies were stable upto a month hence its shelf life was estimated to be good for 40 days. These results underscore the potential of germinated Kodo millet flour as a functional ingredient in developing nutritionally enhanced cookies, offering a healthier alternative to traditional formulations.

Key words: Minerals,, Germination, Gluten, Nutri-cereals,

1. Introduction

Cookies, also known as biscuits in many parts of the world, are among the most cherished and versatile baked products globally. Characterized by their low moisture content typically below 5% they offer a crisp texture and extended shelf life, making them ideal for storage and transport . Traditionally, cookies are developed from refined wheat flour, sugar, and fat, cookies have evolved to include a myriad of ingredients and flavors, catering to

diverse palates. Their convenience as ready-to-eat snacks, affordability, and wide availability have raised their popularity across all age groups . In regions like India, cookies have become integral to daily life, often enjoyed with tea and gifted during festivals . However, with the rise of health consciousness and a shift towards nutritious diets, there's a growing interest in enhancing cookies with whole grains, alternative flours, and natural sweeteners. This evolution not only caters to modern dietary preferences but also offers an opportunity to revisit and incorporate traditional grains like millets, aligning with sustainable and health-focused food trends (1-7).

Millets are small-seeded grasses cultivated globally as cereal crops, and they are recognized for their resilience and adaptability to various climates, particularly in regions with low or erratic rainfall. India stands out as the world's largest millet producer. This study focuses on the nutritional value of millets, which are high in dietary fiber, vitamins, minerals, and proteins (8). Kodo millet (*Paspalum scrobiculatum*) is indigenous to India and is believed to have been domesticated some 3,000 years ago. It is well adapted to the tropics and subtropics and is known by various regional names such as 'kodon' in Hindi, harka in kannada and 'varagu' in Tamil (9). Kodo millet is a rich source of phenolic compounds known for their antioxidant properties. It also contains anti-nutritional factors that can limit its use (10). Incorporating Kodo millet into products like cookies has been successful, with studies indicating that up to 20% substitution maintains desirable sensory qualities (11). millets contain antinutrients like phytic acid that can hinder nutrient absorption; traditional processing methods such as soaking and germination effectively reduce these compounds (12). These processes not only enhance nutrient bioavailability but also improve dough binding and cookie texture, which can be challenging when using unpolished Kodo millet flour (13).

2.0. Objective:

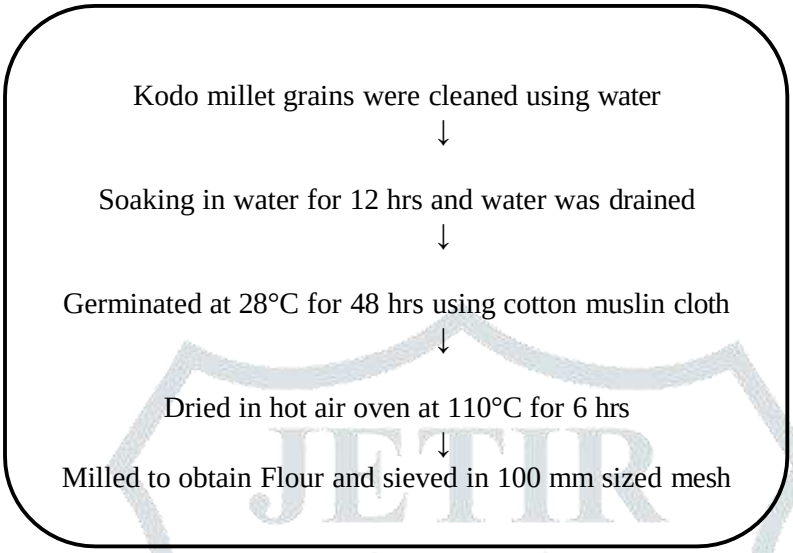
- Development of Cookies from Germinated Kodo Millet Flour
- Evaluation of Sensory Attributes and Nutritional composition
- Analysing the storage stability and microbial growth, and cost analysis of developed product compared with standard

2.1. Materials and Methods

The study was conducted at the Department of Food Science and Nutrition, located in Yuvaraja's College-an autonomous institution affiliated with the University of Mysore in Mysuru. Key ingredients viz., Refined wheat flour, Kodo Millet, Butter, Milk, Sugar, Vanilla essence, Sodium bicarbonate, Baking powder and salt were sourced from the local market of the Mysuru city of different brands. The Germinated and dehydrated Kodo millet was milled in nearby flour mill of the experimental location.

2.2. Preparation of Germinated Kodo millet Flour (GKMF)

Kodo Millet was initially subjected to cleaning, soaking (12 hrs) and Germination (48 hrs), and drying in a hot air oven for 6 hours at 110°C. It was then blended into a fine powder and sieved with a mesh size of 100 mm to obtain a uniform fine powder (14).



Flow chart:01. Preparation of Germinated Kodo millet flour (14).

2.3. Formulation of GKMF Based Cookies

Cookies were developed in four formulations by taking Maida and germinated kodo millet flour in different ratios (V1-80:20, V2-75:25, V3-70:30) with standard (100%) respectively. Other ingredients were used in similar proportions for all the formulations including constant.

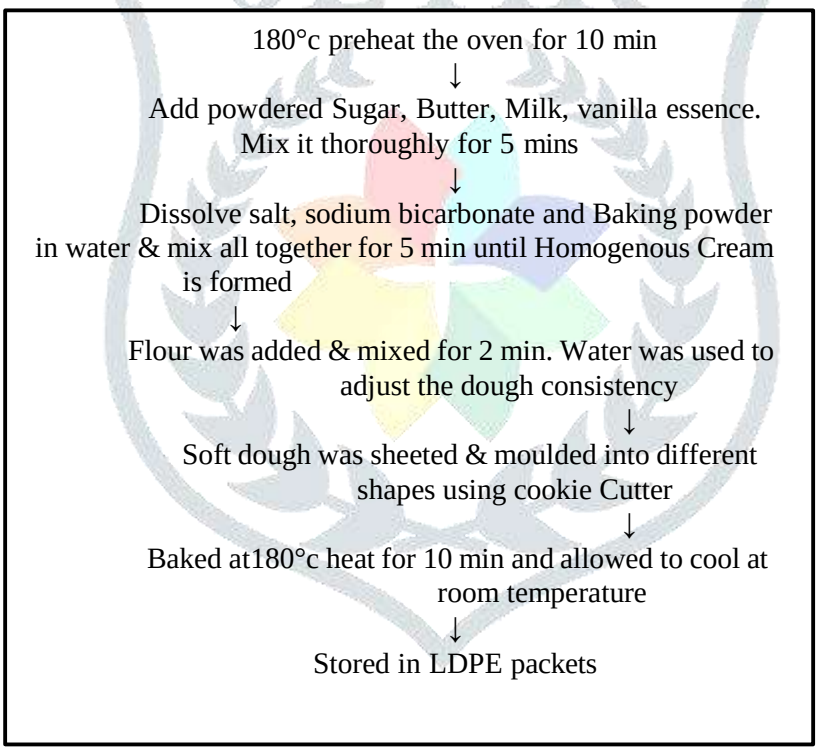
Sl.no.	Ingredients	Standard	V1	V2	V3
1	Refined Wheat Flour (g)	100	80	75	70
2	Germinated KMF (g)	---	20	25	30

3	Powdered sugar (g)	120	120	120	120
4	Unsalted Butter (g)	20	20	20	20
5	Sodium bicarbonate (g)	1.5	1.5	1.5	1.5
6	Vanilla essence (ml)	1	1	1	1
7	Milk (ml)	15	15	15	15
8	Baking Powder (g)	2	2	2	2
9	Salt (g)	0.5	0.5	0.5	0.5

Table. No. 01: Raw materials and its quality for the preparation of cookies in variable proportions
*Note: GKMF incorporated Cookies with three variations (V1- 80:20, V2-75:25, V3-70:30) respectively.

2.4. Method of Preparation of Cookies from GKMF

Dry ingredients were weighed and sieved and mixed with milk and vanilla essence for authentic flavour. Soft dough was prepared and flattened into uniform layer and cut to the desired shapes using moulds. The cookies were baked in a preheated (180°C, 10 mins) oven for 10 mins. Once after cooling at room temperature, cookies were proceeded for further analysis (15).



Flow chart:02. Procedure of Preparation of cookies from GKMF and standard (15)

2.5. Sensory analysis of Cookies:

The developed product underwent evaluation for its organoleptic properties using a nine-point hedonic scale (ranging from 0 to 9), assessed by a panel of semi-trained evaluators. All six formulations, including the control, were reviewed for subsequent analysis (16).

2.6. Proximate Estimation of the cookies:

The nutritional analysis of selected variation and control was conducted in triplicate using A.O.A.C. (2016) methods for basic nutritional composition of developed cookies— comprising moisture and ash (17). Protein, fat, Crude fiber, and carbohydrates—was assessed through standard analytical methods A.O.A.C (2005). To determine moisture content, samples

were dried at 105°C until they reached a consistent weight. Ash content was measured by burning the samples at temperatures of 650–700°C for eight hours and evaluating the leftover inorganic residue. The crude fiber analysis adhered to established protocols, while fat content was extracted using the Soxhlet apparatus with petroleum ether as the solvent. Protein levels were estimated using the Kjeldahl method, applying a nitrogen-to-protein conversion factor of 6.25. The percentage of carbohydrates was calculated by subtracting the total percentages of moisture, fat, crude fiber, protein, and ash from 100 (18).

Carbohydrate (%) = 100 - (% moisture + % fat + % crude fiber + % protein + % ash). (17).

2.6. Storage studies and Microbial Analysis:

The Cookies- Standard and selected Variation samples was evaluated for acceptability and microbiological quality during its storage. Acceptability of the sample was evaluated by the scientific scoring of 9 -point Hedonic scale. The sample was kept up to 30 days at accelerated storage conditions (Temperature 40°C & Humidity 65% RH) and the shelf life was estimated based on the obtained results.

Figure. 2. Storage studies of Cookies made from **1**. Standard (Maida) and **2.** C2 (Maida & GKMF [80:20])

2.7. Statistical analysis:

The obtained results were expressed as the mean value accompanied by the standard error calculated from these replicates. The statistical evaluation was conducted using the designated test, maintaining a predefined threshold for significance at $p \leq 0.05$. This approach enabled a precise interpretation of the experimental data. It also supported the identification of statistical variables among the tested parameters (19).

2.8. Cost analysis of developed product:

The price of developed cookies was analysed and compared with standard including the expenses of raw materials used, labor wages, electricity costs for baking and packaging material charges. Determining the cost of the food product is crucial in order to analyse the research outcome in economic perspective that actually helps for the modification and development cost effective approach for the approval of the product and price fixing (20).

3.0. Results and Discussion:

3.1. Sensory evaluation of cookies

The sensory evaluation of cookies formulated with varying proportions of refined wheat flour (RWF) and Kodo millet flour revealed that the V1 formulation (80:20) achieved the highest overall acceptability among the variations. This blend maintained desirable sensory attributes, closely resembling the standard RWF cookies in appearance, color, flavor, taste, and texture. As the proportion of Kodo millet increased in V2 (75:25) and V3 (70:30), there was a noticeable decline in sensory scores, particularly in flavor and texture, indicating that higher millet content may adversely affect cookie quality. Therefore, the 80:20 RWF to Kodo millet ratio is considered optimal for producing cookies with enhanced nutritional value without compromising sensory appeal.

Cookie formulations	Appearance	Colour	Flavour	Taste	Texture	Overall Accept ability
Standard(RWF)	8.25±0.73	8.05±0.77	7.95±0.8	8.3±0.57	8.2±0.83	8.5±0.54
V1- 80:20	8.02±0.68	7.98±0.76	7.92±0.79	8.18±0.56	8.07±0.79	8.3±0.56
V2 - 75:25	7.83±0.71	7.85±0.75	7.78±0.74	8.10±0	7.96±0.74	7.98±0.49
V3 - 70:30	7.05±1.43	7.45±1.07	6.75 ±1.55	7.35±1.1	6.75±1.01	7.4±1.01

Table 3.1. Sensory scores of Cookies developed from GKMF, values are mean ± SD (n=30) *p value < 0.05

3.2. Proximate Analysis of Developed Cookies:

The selected variation of cookies were subjected for proximate analysis, revealing elevated protein and fat levels attributed to the ingredients used. Germinated Kodo Millet powder contribute rich sources of beneficial polyunsaturated and monounsaturated fats, supporting favourable cholesterol levels and providing additional heart-health advantages. Additionally, the developed GKMF based cookies exhibited high calcium, magnesium, Potassium content. There was slight increase in trace element levels in V1 cookies compared to standard. Milk is a good source of calcium, butter is rich in fats along with kodo millet.

Particularly focusing, the incorporation of germinated Kodo millet flour (GKMF) into cookie formulations significantly enhances their nutritional profile. Compared to standard cookies, GKMF cookies exhibit significant reduction in carbohydrate levels from 74.81 g to
72.11 g, 3.59% increase in protein content (from 7.52 g to 7.79 g) and a 6.77% rise in total fat (from 12.26 g to 13.09 g), attributable to the nutrient-rich composition of GKMF, milk, and butter. Crude fiber content shows a substantial increase (from 0.24 g to 1.74 g), reflecting the high dietary fiber present in germinated millets. Mineral analysis reveals significant upticks in calcium (9.02% increase from 19.19 mg to 20.92 mg), magnesium (95.61% increase from
17.70 mg to 34.61 mg), potassium (11.29% increase from 104.33 mg to 116.11 mg), manganese (39.29% increase from 0.28 mg to 0.39 mg), underscoring the mineral-dense nature of GKMF suggests the potential interactions enhancing its bioavailability. Overall, the integration of GKMF enhances the nutritional profile of cookies, offering potential health benefits. K.T. Mitkal *et al.*, (2021) developed biscuits using a 50:50 blend of kodo millet and refined wheat flour showed

slightly better retention of sensory quality characteristics with enhanced nutritional composition showed that moisture content was 4.11%, protein 10.20%, crude fat 25.70%, crude fiber 4.40%, carbohydrates 69.87%, calcium 25.03 mg/100 g, and iron

2.20 mg/ 100 g respectively (21).

Sl no	Nutrients (unit)	Standard cookies / 100g	GKMF Cookies / 100g
1.	Moisture (%)	2.92	1.85
2.	Energy (kcal)	442.50	447.15
3.	Protein (g)	7.52	7.79
4.	Crude Fiber	0.24	1.74
5.	Total Fat	12.26	13.09
6.	Carbohydrate (g)	74.81	72.11
7.	Ash (g)	2.25	2.42
8.	Potassium (mg)	104.33	116.11
9.	Calcium (mg)	19.19	20.92
10.	Magnesium (mg)	17.70	34.61
11.	Iron (mg)	3.85	3.93
12.	Manganese (mg)	0.28	0.39

Table.no.3.2. Proximate composition of Cookies developed from GKMF compared with standard cookies

3.3. Shelf-life and Microbial Analysis

Sl. No	Test Attributes	Initial-0 day		Storage period (Number of Days)							
		0		10		20		30		40	
	Sensory	S	V1	S	V1	S	V1	S	V1	S	V1
1	Color*	7.5	7.6	7.5	7.6	7.5	7.6	7.4	7.5	7.2	7.5
2	Flavor*	7.6	7.9	7.6	7.8	7.3	7.2	7.2	5.7	6.8	5.1
3	Texture*	7.7	7.7	7.7	7.7	7.7	7.7	7.5	7.6	7.1	7.4
4	Taste*	8.0	8.2	8.0	8.1	7.8	8.0	7.3	6.9	6.0	6.1
5	Overall acceptability*	7.7	7.8	7.7	7.8	7.6	7.6	7.3	7.9	6.7	6.5

Table. 3.3 (a). Accelerated Shelf-life study of Cookies- Standard [S], Germinated kodo Millet Flour Cookies – 80:20 [V1]

*** Scores on nine-point hedonic rating scale, Panel members: 10 no's**

9-point Hedonic scale- 1) Like Extremely**, 2)** Like Very Much, **3)** Like Moderately, **4)** Like Slightly,

5)Neither Like nor Dislike, 6) Dislike Slightly, 7) Dislike Moderately, 8) Dislike Very Much, 9) Dislike Extremely

Sl. No.	Sample type	Test attributes	Initial day 0	Day 10	Day 20	Day 30	Day 40
1	S	TBC (cfu/g)	Absent	$1.8x10^2$	$3.0x10^2$	$8.1x10^2$	$9.4x10^2$
	V1	TBC (cfu/g)	Absent	$2.8x10^2$	$3.9x10^2$	$4.3x10^2$	$8.8x10^2$
2	S & V1	Yeast & Mold count cfu/g	<10	<10	<10	<10	<10
3		Coliforms, cfu/g	<10	<10	<10	<10	<10
4		E. Coli, /g	<10	<10	<10	<10	<10
5		Salmonella / 25g	Absent	Absent	Absent	Absent	Absent
6		Staphylococcus aureus, /g	Absent	Absent	Absent	Absent	Absent
7		Listeria monocytogenes, /25g	Absent	Absent	Absent	Absent	Absent

Table 3.3(b). Microbial Analysis of Standard – [S], Germinated Kodo Millet Flour Cookies (80:20) [V1]

*Total bacterial Count- TBC

The data pertained in the table 3.3 (a) is the accelerated shelf-life study of cookies stored at 40°C and 65% relative humidity over 40 days revealed a gradual decline in sensory attributes—colour, flavor, texture, taste, and overall acceptability. Notably, taste and overall acceptability diminished after 20 days, indicating sensory degradation. Texture remained stable until day 20, followed by a slight decrease.

Microbiological analysis of both samples (Table no.3.3 [b]) showed a steady increase in total bacterial count, yet levels remained within acceptable limits. Yeast, mold, coliforms, E. coli, Salmonella, Staphylococcus aureus, and Listeria monocytogenes were undetectable throughout the storage period, confirming microbiological safety. Based on these findings, the cookies maintained acceptability for up to 40 days under accelerated conditions, suggesting an estimated shelf life of three months under ambient conditions. Mitkal.*et.al.*, 2020 formulated cookies by combining equal parts of kodo millet and refined wheat flours. These treats, when stored in LDPE under ambient conditions for three months, preserved their nutritional integrity and sensory appeal, with LDPE packaging offering marginally superior quality retention (21).

3.4. Cost analysis of cookies:

Sl.no.	Ingredients	Price per 1 kg in Rs	Price per 100 g in Rs	Standard cookies quantity	Price (INR)	V1- Cookies quantity	Price (INR)
1	Refined Wheat Flour (g)	40	4.0	100	4.0	80	3.2
2	Kodo Millet (g)	180	18.0	-	-	20	3.6
3	Powdered sugar (g)	45	4.5	120	5.4	120	5.4
4	Unsalted Butter (g)	600	60	20	12	20	12
5	Sodium bicarbonate (g)	-	33	1.5	0.49	1.5	0.49
6	Vanilla essence (ml)	125/ 20ml	6.25 / ml	1	6.25	1	6.25
7	Milk (ml)	52	5.2	15	0.84	15	0.84
8	Baking Powder (g)	-	36	2	7.2	2	7.2
9	Salt (g)	23	2.3	0.5	Negligible	0.5	Negligible
Production charges [Includes- Processing, Electricity, Labour wages, Packaging material]					6		6
Total cost of cookies per 100 in Rs.					30.18		44.98
Total cost of cookies per Kg in Rs.					301.8=302		449.8 =450

Table.3.4. Cost analysis of the cookies –**S** -Standard and variation (V1- 20% GKMF)

This study aimed to estimate the production cost of cookies od selected variation made with Refined wheat flour, germinated kodo millet flour, butter, milk, good quality vanilla essence, baking powder and baking soda and salt of different brands and The findings revealed that the production cost of the standard cookies was lower (Rs. 302/kg) compared to 20% GKMF incorporated cookies (Rs. 450/kg), attributed to the higher nutrient content of the GKMF based cookies. Mitkal K T *et.al.*, in 2021 revealed the cost analysis results as its price was 122 Rs per Kg (21). Here in this study the cost elevation was due to the usage of butter instead of Vanaspati, vanilla essence and Milk and also processing of Kodo Millet viz., germination, drying, milling cost as additional contributions.

4.0. Conclusion:

The present study of incorporating germinated Kodo millet flour (GKMF) into cookies at a 20% ratio with refined wheat flour enhances their nutritional profile without compromising taste and texture. This variation (V1) maintains sensory qualities similar to standard cookies while boosting protein, fat, fiber, and essential minerals like calcium and magnesium. Hence, overall nutritional benefits were significant. Shelf-life studies indicate that these cookies remain microbiologically safe and sensorially acceptable for up to 40 days under accelerated conditions, suggesting a three-month shelf life at room temperature. Additionally, the lower glycemic index with enriched fibre and lowered carbohydrates of kodo millet incorporation

References:

Mitkal, K. T., Kotecha, P. M., Godase, S. N., & Chavan, U. D. (2020). Studies on utilization of kodo millet flour in the preparation of biscuits. International Journal of Current Microbiology and Applied Sciences, Special Issue-11, 4104–4111.

Shanmugapriya, N. S., Tousif, R. M., & Priya, S. R. (2022). Sensory analysis of cookies made using different types of millet. International Journal of Innovative Research in Technology, 8(12), 1299– 1303. https://ijirt.org/Article?manuscript=155082

Britannica. (n.d.). Cookie | Definition, types, & ingredients. Encyclopedia Britannica. Retrieved May 9, 2025, from https://www.britannica.com/topic/cookie-food

Market.us Media. (2025). Cookies statistics and facts. Retrieved May 9, 2025, from https://media.market.us/cookies-statistics/

IMARC Group. (n.d.). India cookies market size, share, industry trends 2025–33. Retrieved May 9, 2025, from https://www.imarcgroup.com/india-cookies-market

Food & Beverage News. (n.d.). Cookies market in India: A delightful present for several occasions. Retrieved May 9, 2025, from https://www.fnbnews.com/Bakery-Biscuits/cookies-market-in-india-a- delightful-present-for-several-occassions-79357

Mintel. (n.d.). The growing appetite for premium sweet biscuits and cookies in India. Retrieved May 9, 2025, from https://www.mintel.com/insights/food-and-drink/the-growing-appetite-for-premium-sweet- biscuits-and-cookies-in-india/

Nutritional and health benefits of millets: A review article. (2024). Journal of International Society of Sports Medicine, 10(1), 1–10. https://journals.lww.com/jism/fulltext/2024/12010/nutritional_and_health_benefits_of_millets a.2.asp x

Origin, domestication, taxonomy, botanical description, genetics and cytogenetics of Kodo millet (Paspalum scrobiculatum). (n.d.). Current Research, 7(1), 1–5. https://www.journalcra.com/article/origin-domestication-taxonomy-botanical-description-genetics-and- cytogenetics-genetic-1

Kodo millet: Technological impact and nutritional benefits for value addition. (2024). Journal of Food Processing and Engineering, 47(3), e14655. https://onlinelibrary.wiley.com/doi/10.1111/jfpe.14655

Studies on nutritional quality of Kodo millet cookies. (2021). International Journal of Chemical Studies, 9(1), 1669–1674. https://www.chemijournal.com/archives/?ArticleId=11465&issue=1&si=false&vol=9&year=2021(che mijournal.com)

Singh, T. B., & Kaushik, R. (2025). Mitigation of anti-nutrients from millet by employing traditional to modern processing techniques. Food Research International, 162, 112345. https://doi.org/10.1016/j.foodres.2025.112345

Preparation of healthy cookies from germinated flour blends of millets. (2024). Journal of Advanced Pediatric and Child Health, 2(1), 1–5. https://www.pediatricshealthjournal.com/articles/japch- aid1064.php

Chandraprabha, S., & Sharon, L. (2021, April 20). Optimisation of conditions for barnyard millet germination. Plant Archives, 21(1), 1676–1680. https://doi.org/10.51470/PLANTARCHIVES.2021.v21.no1.230

Kumar, K. A., Sharma, G. K., Khan, M. A., & Semwal, A. D. (2015). Optimization of multigrain premix for high protein and dietary fibre biscuits using response surface methodology (RSM). Food and Nutrition Sciences, 6(6), 747–756. https://doi.org/10.4236/fns.2015.69077(ResearchGate)

Srilakshmi, B. (2018). Food science (7th ed.). New Age International (P) Ltd., Publishers.

Association of Official Analytical Chemists. (2016). Official methods of analysis (20th ed.). AOAC International.

Association of Official Analytical Chemists. (2005). Official methods of analysis (18th ed.). AOAC International.

Rai, B. S., Shukla, S., Kishor, K., Singh, H., & Dey, S. (2017). Studies on cost of production for value added prepared mixed flour biscuit. International Journal of Chemical Studies, 5(4), 1904–1905

Mitkal, K. T., Kotecha, P. M., Godase, S. N., & Chavan, U. D. (2021). Studies on nutritional quality of Kodo millet cookies. International Journal of Chemical Studies, 9(1), 1669–1674. https://doi.org/10.22271/chemi.2021.v9.i1x.11465(ResearchGate)