International Journal of Science and Research Archive

eISSN: 2582-8185

Cross Ref DOI: 10.30574/ijsra

Journal homepage: https://ijsra.net/

(RESEARCH ARTICLE)

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Standardisation and quality evaluation of millet-based Chikki using Quinoa and Bajra

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International Journal of Science and Research Archive, 2024, 23(02), 2511–2517

Publication history: Received on 14 July 2024; revised on 20 August 2024; accepted on 23 August 2024

Article DOI: https://doi.org/10.30574/ijsra.2024.12.2.1556

Abstract

Millet Chikki is a nutritionally enriched snack crafted from millet grains, an ancient gluten-free staple. This innovative take on traditional Chikki blends the goodness of millets with essential nutrients, catering to modern health-conscious consumers. Since, millets are known to be rich in proteins, fibre, vitamins, and minerals, it provides a sustainable source of energy. This study focuses on the standardization and quality evaluation of millet-based Chikki incorporating quinoa and bajra, with jaggery syrup as a sweetener. Three different formulations of Chikki were prepared: Sample-A (60% roasted quinoa, 30% jaggery syrup, 10% other ingredients), Sample-B (60% roasted bajra, 30% jaggery syrup, 10% other ingredients), and Sample-C (30% roasted quinoa, 30% roasted bajra, 30% jaggery syrup, 10% other ingredients). Sensory evaluation revealed that Sample-A had superior sensory attributes, including aroma, appearance, texture, taste, and overall acceptability, compared to Sample-B and Sample-C. Nutritional analysis showed that Sample-A had the highest energy content (699 kcal/100g) and a balanced nutrient profile. Antioxidant assays demonstrated significant free radical scavenging and reducing capabilities in Sample-A, while microbiological analysis confirmed its safety with low microbial load and absence of harmful pathogens. These findings highlight that the inclusion of roasted quinoa enhances both the sensory appeal and nutritional value of millet-based Chikki, making Sample-A the optimal formulation.

Keywords: Quinoa; Bajra; Millet Chikki; Organoleptic properties; Nutritional parameters

1. Introduction

Millet, being a versatile crop, serves various purposes in India beyond its primary role as a food source. It finds application in decortication, milling, puffing, and the production of puffed/popped and flaked millets. Additionally, millet is used to create a diverse range of products such as pasta, noodles, baked goods, extruded products, fermented foods, malting, and weaning foods. Furthermore, millets contribute to the development of healthy and functional foods, as well as the preservation of traditional foods and beverages, showcasing their multifaceted nature and adaptability (Saraswathi R and Hameed R S., 2022).

Quinoa is rich in protein, fiber, and essential vitamins and minerals, including iron and manganese. Its ability to thrive in poor soil conditions and high altitudes made it an ideal crop for the Andean regions' quinoa was largely replaced by cereals like wheat and barley following the Spanish conquest. However, it has seen a resurgence in recent decades due to its nutritional benefits and adaptability, gaining popularity worldwide as a health food Quinoa's versatility extends beyond its nutritional benefits; it can be used in a variety of dishes, from breakfast cereals to hearty dinners. It can be cooked similarly to rice and incorporated into salads, soups, and even desserts (Amanda Fiegl 2009).

Bajra, also known as pearl millet, is one of the oldest cultivated grains, originating in Africa and later introduced to India. The consumption of bajra is linked to several health benefits. It aids in weight management due to its high fiber content, which promotes a feeling of fullness. Bajra also has a low glycemic index, making it suitable for individuals with diabetes.

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Additionally, its antioxidants help in reducing oxidative stress and inflammation in the body (Dayakar Rao, B., Bhaskarachary, K., Arlene Christina, G.D., Devi, G.S., and Vilas A. Tonapi)

Jaggery, also known as "gur" in India, is a traditional, non-centrifugal sugar made by boiling sugarcane juice until it solidifies. The process retains many of the natural minerals and nutrients found in sugarcane, making jaggery a healthier alternative to refined sugar. Recent studies highlight the nutritional benefits of jaggery, noting its rich content of minerals like iron, magnesium, and potassium, as well as antioxidants and phenolic compounds that provide health benefits such as improved digestion and enhanced immune function. For example, a study by (Dedhia et al.) emphasizes the importance of maintaining the nutritional quality of jaggery by optimizing the juice clarification process to retain these beneficial components (Ashok Kumar S and Priyanka Singh). Quinoa, bajra and jaggery were included in the recipe to enhance the nutritional value of the Chikki. Jaggery was used as the sweetener. Hence present study was formulated on Standardization and Quality Evaluation of (Millet) based Chikki from quinoa and bajra.

2. Materials and method

2.1. Procurement of Materials

The raw materials selected for this study were quinoa, bajra, jaggery and ghee were purchased from the local market in Shapur Nagar, Hyderabad. The present study was carried out in Capital Degree and PG College, Hyderabad, Telangana, India.

2.2. Preparation of Millet Based Chikki

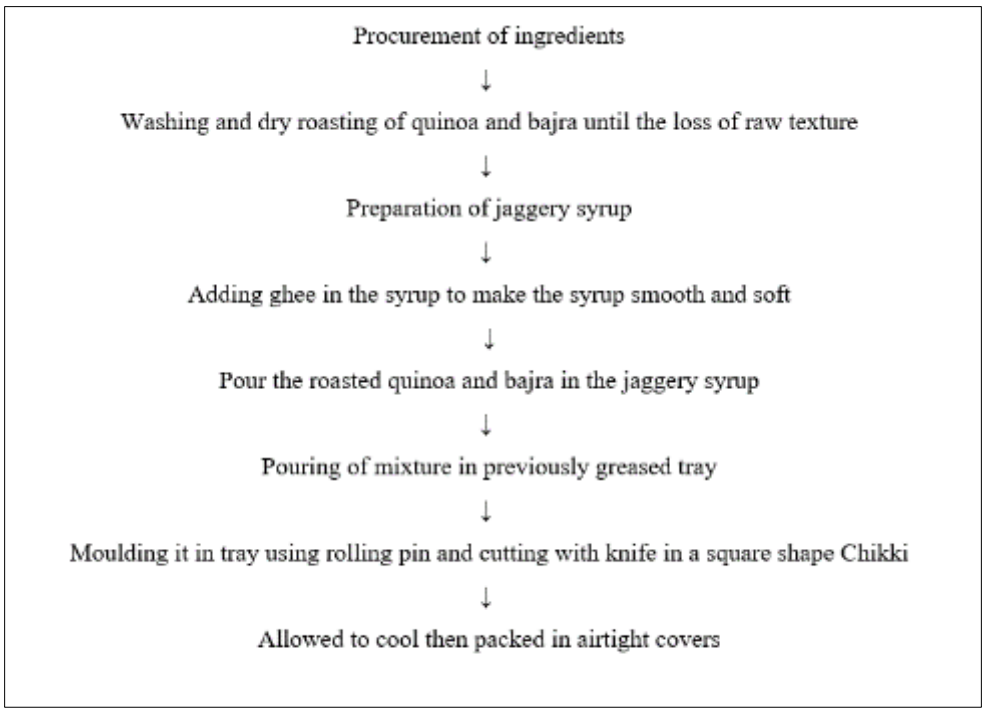

Figure 1 Preparation of millet-based Chikki

Chikki was prepared by taking jaggery, roasted bajra and quinoa (Fig 1). Jaggery was crushed and made into syrup with addition of ghee. The clear jaggery syrup was heated until the temperature reaches to 150 ℃, immediately pre –weighed roasted millets were added according to the different formulations given in table-1 then mixed thoroughly till the millets get coated with jaggery syrup. Hot mass was then transferred on to a wooden board. Which was greased with ghee. The product was then spread uniformly by rolling it with the help of a roller. Vertical and horizontal lines were marked with a cutter to make individual slabs then cooled to room temperature and then were packed in polythene pouches (Fig 2, Fig 3 and Fig 4).

Figure 2 Bajra Chikki

Figure 3 Quinoa Chikki

Figure 4 Quinoa bajra Chikki

2.3. Formulation of Chikki

Three combinations of millet-based Chikki were formulated by different various proportions of pearl millet and quinoa as follows (Table 1).

Table 1 Formulation for the preparation of Chikki

Samples	Combinations
Sample-A	60%RQ + 30%JS + 10%OI
Sample-B	60%RB + 30%JS + 10%OI
Sample-C	30%RB + 30%RQ +30%JS + 10%OI

RQ – Roasted Quinoa, RB – Roasted Bajra, JS – Jaggery Syrup, OI – Other Ingredients.

2.4. Sensory evaluation

The sensory evaluation of the samples was done by the scorecard method, which mainly consists of six parameters: aroma, appearance, taste, texture, mouthfeel, and overall acceptability. A 5-point hedonic scale is used. Based on the organoleptic scores the best sample is selected out of three samples.

2.5. Nutrient analysis of the samples

Nutrient analysis of the selected sample is performed to know the values of energy, carbohydrates, total fat, total sugars, protein, moisture and dietary fiber. The nutrient analysis of the best-selected sample was analysed as follows (Table 2).

Table 2 Nutritional Qualities and Method of the millets Chikki

Nutritional qualities	Methods
Energy	FAO method
Carbohydrate	CTL/SOP/FOOD/262-2014
Total fat	AOAC 20th Edn.2016, 920.39
Protein	AOAC 20th Edn.2016, 986.25
Dietary fibre	AOAC 20th Edn.2016, 985.29
Total sugars	FSSAI Manual 2015-Beverages, Sugars, and Confectioneries

2.6. Antioxidant analysis of Millets Chikki

The antioxidant activity of food samples was evaluated using assays: DPPH (2,2-diphenyl-1-picrylhydrazyl), FRAP (Ferric Reducing Antioxidant Power. Each assay was conducted following standardized procedures (Table 3).

Table 3 Antioxidant activity of the Millets Chikki

Antioxidant activity	Units	Method
DPPH	ppm	Brand-Williams et al., 1995
FRAP	µmol Fe +2 /g	Benzie & Strain (1996)

- **DPPH Method-** (2,2-Diphenyl-1-picryhydrazyl) is a method for determination of antioxidant activity in the selected food sample. (Brand-Williams et al., 1995)
  Antioxidant activity (%) = [(Absorbance of the DPPH solution without sample – Absorbance of the DPPH solution with sample) / Absorbance of the DPPH solution without sample control] x 100
- **FRAP Method–** (Ferric Reducing Antioxidant Power) is a method for determination of antioxidant activity in the selected food sample. (Benzie and Strain, 1996)
  FRAP value (µmol TE/g) = (Absorbance of the sample- Absorbance of the blank) / (Absorbance of the Trolox standard – Absorbance of the blank) x Concentration of Trolox standard (µmol/ml) x Dilution factor.

2.7. Microbiological Analysis

Microbial analysis such as aerobic plate count, yeast & molds and Enterobacteriaceae was carried out for 30 days of study by procedure followed by Indian standard method. (FSSAI Manual, 2nd Edn.2022).

2.8. Statistical analysis

Statistical analysis was done with Mean, Standard deviation, and ANOVA by using their formulas

3. Results and discursion

3.1. Sensory Analysis and identification of best sensory attributes

In the sensory evaluation of the three samples (Table 4), Sample-A demonstrated superior sensory attributes, scoring highest across all criteria including aroma (4.81±0.07), appearance (4.64±0.09), texture (4.63±0.09), taste (4.75±0.13), mouthfeel (4.70±0.07), and overall acceptability (4.75±0.13). This can be attributed to its composition of 60% roasted quinoa and 30% jaggery syrup, which likely enhanced its sensory appeal. In contrast, Sample-B, composed of 60% roasted bajra and 30% jaggery syrup, received the lowest scores across all attributes, with aroma (2.93±0.11), appearance (2.88±0.13), texture (2.88±0.12), taste (2.92±0.13), mouthfeel (2.88±0.12), and overall acceptability (2.92±0.13) indicating less favorable sensory characteristics. This suggests that the high proportion of roasted bajra may have negatively impacted its sensory qualities. Sample-C**,** with an even mix of roasted bajra, roasted quinoa, and jaggery syrup, presented intermediate scores, with aroma (3.53±0.09), appearance (3.50±0.07), texture (3.53±0.10), taste (3.55±0.13), mouthfeel (3.53±0.09), and overall acceptability (3.55±0.13). While balanced, it did not achieve the sensory excellence of Sample-A. These results highlight the significant influence of ingredient composition on sensory quality, with roasted quinoa and jaggery syrup combinations yielding the most favorable outcomes.

Table 4 Sensory Parameters of millet chikki samples

Attributes	Sample-A	Sample B	Sample C
Aroma	4.81±0.07	2.93±0.11	3.53±0.09
Appearance	4.64± 0.09	2.88±0.13	3.50±0.07
Texture	4.63±0.09	2.88±0.12	3.53±0.10
Taste	4.75±0.13	2.92±0.13	3.55±0.13
Mouthfeel	4.70±0.07	2.88±0.12	3.53±0.09
Overall Acceptability	4.75±0.13	2.92±0.13	3.55±0.13

The ANOVA results indicate a statistically significant difference in sensory attributes among the Chikki samples, with an F-value of 3.79 and a P-value of 0.047, which is below the critical value of 3.163. This suggests that the variations in sensory scores across the samples are unlikely to be due to random chance, highlighting significant differences in

sensory qualities. Specifically, Sample-A scored significantly higher in aroma, appearance, texture, taste, mouthfeel, and overall acceptability compared to Sample-B and Sample-C. The lower scores for Sample-B in all attributes suggest it is less preferred, likely due to its higher roasted bajra content which may have adversely affected its sensory properties.

where Sample-A, which had the highest proportion of roasted quinoa and jaggery syrup, was favored for its superior sensory attributes. These findings underline the importance of ingredient formulation in developing products with desirable sensory characteristics.

Table 5 Calculated ANOVA Values for the Means Samples

Source of variation	SS	df	MS	F	P-Value	F Critical
Between groups	2.85881944	2	1.429409723	3.78554088	0.046670412	3.1634222
Within groups	5.66395833	15	0.37759722			
Total	8.52277777	17				

3.2. Nutritive value of differently treated millet Chikki

The nutritional analysis of the selected Chikki samples revealed distinct profiles for each formulation (Table 6). Sample-A exhibited the highest energy content at 699 kcal/100 g, alongside 80.97 g/100g of carbohydrates, 0.18 g/100g of total fat, 9.77 g/100 g of protein, and 2.6 g/100 g of dietary fiber. Reducing sugars were 1.26 g/100 g, and moisture content was 8.4 g/100 g. In comparison, Sample-B had the lowest energy content (480 kcal/100 g) but similar carbohydrate (80.77 g/100 g) and fat (0.17 g/100 g) levels, with slightly higher moisture (8.6 g/100 g) and comparable fiber (2.6 g/100 g). Sample-C also had an energy content near Sample-A (697 kcal/100 g) but lower fiber (2.4 g/100 g) and slightly higher ash content (1.6 g/100 g). The results align with similar studies, such as Priyanka Goswami's 2015 research, which highlighted the nutritional benefits of using millets in food products, enhancing protein and fiber content. The variations in energy content and nutrient composition among the samples can be attributed to their differing ingredient proportions, affecting overall nutritional density and quality. similar study were conducted by (Priyanka Goswami 2015) on "Formulation and Development of Nutri-rich Ragi (*Eleusine coracana* L.) food products" were rich in protein and dietary fiber due to the usage of millets.

Table 6 Nutritive Values of Sample-A Sample-B and Sample-C of Millet Chikki

parameters	S-A	S-B	S-C	Units
Reducing sugar	1.26	1.25	1.23	g/100g
fat	0.18	0.17	0.17	g/100g
protein	9.77	9.76	9.95	g/100g
moisture	8.4	8.6	8.3	g/100g
ash	1.5	1.4	1.6	g/100g
carbohydrates	80.97	80.77	80.77	g/100g
fiber	2.6	2.6	2.4	g/100g
energy	699	480	697	kcal/100g

3.3. Total Antioxidant Property by DPPH Method

The total antioxidant capacity of Sample-A was assessed using DPPH and FRAP assays (Table 7). The DPPH assay revealed an antioxidant activity of 1277 ppm, indicating a high level of free radical scavenging ability in Sample-A. The FRAP assay, measuring the ferric reducing antioxidant power, recorded a value of 9.789 µmol, which reflects the sample's capacity to reduce ferric ions to ferrous ions.

These results suggest that Sample-A possesses substantial antioxidant properties, with free radical scavenging and reducing capabilities. The high DPPH and FRAP values shows the effectiveness of the antioxidants present in Sample-A, highlighting its potential health benefits related to oxidative stress reduction.

Table 7 Total Antioxidant Property of the Millet Chikki (Sample A)

Test parameters	Sample-A	Units
DPPH	1277	Ppm
FRAP	9.789	umol

3.4. Determination of Microbiological Analysis During One Month of Storage

The microbiological assessment of Sample-A millet Chikki revealed favorable results (Table 8). The total viable count was measured at 100 CFU/ml, indicating a low level of microbial load, which is acceptable for this type of product. Yeast and mold counts were below 10 CFU/ml, signifying minimal fungal contamination. Importantly, the absence of *E. coli*, *coliforms*, *Salmonella*, and *Staphylococcus confirms* that Sample-A is free from these harmful pathogens, ensuring its safety for consumption.

These microbiological parameters underscore the high quality and safety of Sample-A. The low microbial load and absence of specific pathogens suggest that the Chikki was produced and handled under hygienic conditions, adhering to safety standards. Yeast and Mold remained constant during storage. Meherunnahar et al (2023) foxtail millet noodles were stored for 6 months and the microbial load was within limits. Sarojini JK et al (2021) The ready-to-cook kodo millet pasta was stored for 3 months and there were significant changes in the pasta, The pasta became rancid after 3 months of storage.

Table 8 Microbiological Parameters of the Millet Chikki (Sample A)

Test Parameter	Results	Units
Total viable count	100	CFU/ml
Yeast and Molds	<10	CFU/ml
E. coli	absent	CFU/ml
Coliform	absent	CFU/ml
Salmonella	absent	CFU/ml
Staphylococcus	absent	CFU/ml

4. Conclusion

The study effectively evaluated the quality and safety of millet-based Chikki formulated with varying proportions of roasted quinoa and bajra, along with jaggery syrup. Sample-A, containing 60% roasted quinoa, 30% jaggery syrup, and 10% other ingredients, demonstrated superior sensory attributes, nutritional profile, antioxidant capacity, and microbiological safety compared to Sample-B and Sample-C. With the highest scores in aroma, appearance, texture, taste, and overall acceptability, Sample-A stands out for its favorable sensory qualities. Nutritional analysis indicated that Sample-A offers the highest energy content and a balanced nutrient profile. Its significant antioxidant activity and low microbial load further underscore its potential health benefits and product safety. These findings suggest that the formulation with a higher proportion of roasted quinoa enhances both sensory appeal and nutritional value, making Sample-A a preferable choice for millet-based Chikki.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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