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ORIGINAL ARTICLE

Nutritional and Microbial Profile of Black Rice (*Oryza sativa L.indica*) and Chickpea (*Cicer arietinum L.*) Ladoo

S. Bhavatharani[1], Krishnan Nandita[2]*, A. J. Hemamalini[3]

1 PostGraduate, Department of Clinical Nutrition, Faculty of Allied Health Sciences, Sri Ramachandra Institute of Higher Education and Research (Deemed to be University), Porur, Chennai-116, Tamil Nadu, India
2 Lecturer, Department of Clinical Nutrition, Faculty of Allied Health Sciences, Sri Ramachandra Institute of Higher Education and Research (Deemed to be University), Porur, Chennai-116, Tamil Nadu, India
3 Professor and Head, Department of Clinical Nutrition, Faculty of Allied Health Sciences, Sri Ramachandra Institute of Higher Education and Research (Deemed to be University), Porur, Chennai-116, Tamil Nadu, India

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* **Corresponding author**.

nanditakrishnan@sriramachandra.edu.in

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Abstract

Aim: To formulate and standardize the sensory, nutritional, and microbial analysis on Black Rice (*Oryza sativa L. indica*) and chickpea (*Cicer arietinum L.*) Ladoo for obesity**. Objective:** The study aimed to formulate and standardize Black Rice (*Oryza sativa L. indica*) and Chickpea (*Cicer arietinum*) ladoo, evaluating its sensory acceptability, nutritional composition, and microbial safety to address obesity. **Methods:** Three variations of black rice and chickpea ladoo were developed in a controlled environment. Sensory evaluation was conducted by thirty panelists using a nine-point hedonic scale. The most accepted variation (Trial 3) was subjected to nutrient analysis, microbial shelf-life testing, and phytochemical screening to assess its functional properties. **Findings:** The organoleptic evaluation indicated high acceptability, and the selected formulation provided 116.63 mg of calcium, 7.18 mg of iron, and 1.72 mg of zinc per serving. The ladoo also exhibited a favorable microbial shelf life, suggesting its potential as a functional food for weight management. **Novelty:** This study may also be used to determine the effectiveness of black rice, which has been shown to have numerous useful qualities, for non-consumers and to provide black rice consumers more options for their diets. It also highlights the sensory acceptability and nutritional benefits of a traditional, yet modified snack aimed at promoting better health outcomes.

Keywords: Black rice; Chickpea; Obesity; Low glycemic index; Nutrient analysis

1 Introduction

Rice is the most important cereal crop in the world. Regular consumers comprise almost 50% of the global population. Asia is where 95% of the world's rice is grown.[(1)] Most rice consumed worldwide is white, however numerous unique varieties include

color pigments, including black rice, red rice, and brown rice. Their names reflect the colors that characterize the kernels, which are produced by deposits of anthocyanin at different levels in the pericarp, seed coat, and aleurone. The colors of the kernels include black, red, and purple. As a result, black rice is a universal treatment for many illnesses.[2] Black rice is a whole grain type that is not only a source of carbohydrates and fibers but also characterized by substantial contents of diverse classes of bioactive metabolites including phenolic acids, flavonoids, anthocyanins, proanthocyanidins, and tocotrienols.[3] Black rice is considered a great source of anthocyanins, which can lower the risk of obesity and cancer. Additionally, the substances in black rice have anti-inflammatory, antiviral, and anti-aging properties.[4] Black rice, a variety of rice (*Oryza sativa L.*), is one of the more nutrient-dense types of rice and a great provider of many different nutrients. Essential amino acids like lysine and tryptophan, minerals like iron, calcium, phosphorus, zinc, and selenium, and vitamins like folic acid and vitamins B1 and B2 are all found in good amounts.[4] Black rice has a lot of minerals, including calcium and iron (21.38 mg/100g). All samples, except for the black rice (10.19 mg/100g), have minimal sodium content. Potassium level is high (186.54 mg/100 g) and magnesium content is high (107.21 mg/100 g) Black rice (5.89%) had maximum overall amounts of both unsaturated and saturated fatty acids of all the rice cultivars examined.[5] Clinical studies also showed that anthocyanins helped to improve learning capacity and reduce symptoms of depression. Adding black rice to the diet helps boost memory and prevent premature cognitive aging.[5] Black rice consumption may promote heart and liver health, weight loss, blood glucose level and lipid profile control, and prevention and control of inflammation and cancer.[6]

Legumes are versatile crops that are used in many agricultural practices as feed, food, or various processing forms. In addition to being a healthy source of fiber, vitamins, minerals, and protein, chickpeas also contain phytochemicals that may benefit your health.[7] Compared to other dry edible grain legumes, it has the highest nutritional composition and no anti-nutritive components, thus making it a functional food or nutraceutical. The estrogenic activity suggested by the isoflavone content in chickpeas, along with its hypoglycemic properties and hypolipidemic effects, may be beneficial in treating hormonal and metabolic disorders associated with PCOS.[8]

Chickpeas are an inexpensive and vital source of protein for persons who cannot afford animal protein or are primarily vegetarian. In addition, chickpeas are a good source of fiber, unsaturated fatty acids, and minerals like calcium, phosphorus, magnesium, zinc, and iron.[9] Chickpeas are important for preserving soil fertility because they can fix nitrogen at rates of up to 140 kg per hectare per year. Chickpeas add organic matter and a sizable amount of residual nitrogen to the soil, enhancing its health and fertility.[10] This research aims to build a product that explores the nutritional content, phytochemicals, and bioactive substances of black rice, including phenolic compounds and flavonoids, as well as their health advantages. In addition, black rice has been used in medicine to treat cancer, diabetes, obesity, and heart disease. Black rice, a variety of rice (*Oryza sativa L.*), is one of the more nutrient-dense types of rice and a great provider of many different nutrients. Essential amino acids like lysine and tryptophan, minerals like iron, calcium, phosphorus, zinc, and selenium, and vitamins like folic acid and vitamins B1 and B2 are all found in good amounts in it.

In this study, black rice in different proportions was added to replace the white rice for the preparation of ladoo. This study's major objective was to popularize black rice consumption in areas where it is not consumed. There are some studies on the enrichment of ladoo with millet, quinoa, various rice, etc., but there are no studies on the combination of preparation using black rice and chickpea. Hence, the present study was undertaken to prepare and evaluate ladoo by incorporating different proportions of black rice and chickpea in traditional white rice-based ladoo.

The combination of black rice and chickpeas offers a nutritionally dense and innovative approach to traditional food preparation. This study aims to explore the potential health benefits and consumer acceptance of black rice and chickpea ladoo, which could serve as a functional food option for health-conscious individuals.

This study aims to develop and analyze the sensory, nutritional, and microbial analysis on Black Rice (*Oryza sativa L. indica*) and chickpea (*Cicer arietinum L.*) Ladoo for obesity with the following objectives:

- To standardize and develop a ladoo with Black rice (*Oryza sativa L. indica*) and chickpea (*Cicer arietinum L.*).
- To analyze the sensory, nutritional, microbial attributes and shelf life of the Black rice *Oryza sativa L.* and chickpea (*Cicer arietinum L.*) ladoo**.**

Ethical and Humane Considerations:

The Ethical Approval was obtained by the Institutional Committee of Sri Ramachandra Institute of Higher Education and Research (deemed to be a university), Porur, Chennai- 116 **(CSP/23/JUL/132/675)**.

2 Methodology

Utilizing locally accessible foods created new nutritional items. For the produced product, an organoleptic assessment and a nutritional content study were performed. Standardization was carried out to determine whether the goods containing the

components were pleasant and acceptable. Three distinct items were created following the correct standards and hygienic practices.

2.1 Phase-I: Preparation of Products

The ingredients such as Black rice (*Oryza sativa L. indica*), Chickpea (*Cicer arietinum L.*), ginger powder, cumin powder, fenugreek, fennel seeds, honey, and ghee were collected with the help of local markets. The novel dietary products were prepared on the college campus at the food science lab, Department of Clinical Nutrition, SRIHER, Chennai. Three different types of dietary products were developed namely:

- Trial-1
- Trial-2
- Trial-3

Procurement of Ingredients:

The ingredients for the recipes were purchased from the local market, in Chennai.

Standardization of the Recipes:

As a part of the recipe standardization process, three trials were carried out until an appropriate recipe for preparing the product was found. The final quantities were decided by comparing the differences in appearance, texture, and flavor.

Table 1. Ingredients used

Product Name: Black Rice Ladoo			
Ingredients used	**Quantity used**		
	Trial-1	**Trial-2**	**Trial-3**
Black Rice (*Oryza Sativa L. Indica*)	15	10	15
Chickpea (*Cicer Arietinum L.*)	15	15	10
Ginger Powder	1	5	5
Cumin Powder	1	2	2
Fenugreek	2	2	2
Fennel Seeds	1	1	1
Honey	2.5	2.5	2.5
Ghee	2.5	2.5	2.5
Total	40g	40g	40g

2.2 Phase- II: Organoleptic Evaluation

Organoleptic evaluation involves inspecting a food product using five senses, such as appearance, taste, flavor, color, and texture. The panel of sensory evaluators consists of 30 members. Organoleptic evaluation scores of the developed dietary product were based on a hedonic scale.

The product was evaluated for Appearance, Taste, Flavor, Color, Texture, and Overall acceptability. The scorecard used in the study was a Hedonic 9-point scale according to the standard procedures. The scorecards were given to the sensory evaluators to evaluate the developed dietary products.

The different scores used in the hedonic scale are given in Table 2. Following organoleptic evaluation, the finalized product has been given for nutrient analysis to analyze the nutrient composition.

An experienced nutrition panel composed of 5 panelists from the Department of Clinical Nutrition, Sri Ramachandra Institute of Higher Education and Research, assessed the acceptability of the developed recipes using the 9-point hedonic scale. After introducing the organoleptic process to five random members from each community – Children, Adolescents, Non-Nutritionists, Adult Men, and Adult Women, consumer acceptance of the recipes was evoked. As a result, the 30 panelists conducted organoleptic evaluations for all three trials to determine overall recipe preferences ranging from taste, flavor, color, texture, appearance, and overall acceptability.

The developed recipe was analyzed for its Energy (Kcal), Carbohydrate (g), Protein (g), Fat (g), Fibre (g), Sodium (mg), Iron (mg), and Calcium (mg). The Weighted quantity (100g) of the finalized recipe was packed in an air-tight container and given to the laboratory for analysis. Shelf-life of the product was also analyzed in the same laboratory

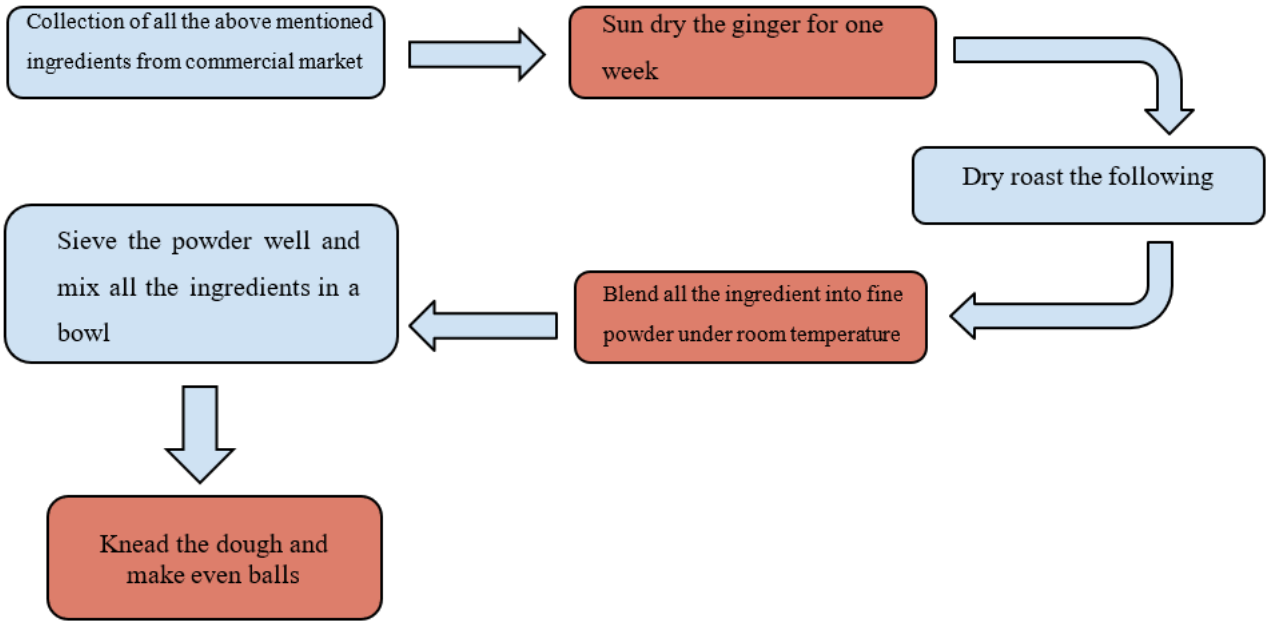

Fig 1. Method of preparation

Table 2. Different scores used in the Hedonic 9-point scale

Term	Grade
Dislike extremely	I
Dislike very much	II
Dislike moderately	III
Dislike slightly	IV
Neither like nor dislike	V
Like slightly	VI
Like moderately	VII
Like very much	VIII
Like extremely	IX

Fig 2. Phase III Nutrient Analysis is a separate Heading Kindly feature it below the picture

2.3 Cost Analysis

The overall cost of the study includes many direct and indirect expenditures. The cost of each ingredient was determined in the local market, and the total cost, including the overhead expenses, was estimated.

3 Result

The developed dietary products were evaluated for their organoleptic properties and nutrient composition.

3.1 Sensory Evaluation

Table 3 shows the average score of organoleptic evaluation of three trials of black rice and chickpea ladoo.

Trial 1: The Appearance (7.2), Colour (7.2), Taste (6.5), Texture (6.6), Flavour (6.6) and Overall Acceptability (6.68) was ranked as slightly lesser in taste.

Trial 2: The Appearance (7.2), Colour (7.2), Taste (7.4), Texture (7.06), Flavour (7.2) and Overall Acceptability (7.44) was ranked as slightly moderate in taste.

Trial 3: The Appearance (7.37), Colour (7.51), Taste (7.10), Texture (7.24), Flavour (7.24) and Overall Acceptability (7.62) was ranked as highly liked in taste and overall acceptability.

3.2 Nutrient Analysis

The nutritional analysis of the developed Black Rice and Chickpea ladoo, as tested in a NABL-approved laboratory, revealed a well-balanced composition of macronutrients and micronutrients. The recipe provided **382.78 kcal**, **65.67 g carbohydrates**, **9.90 g fat**, **7.75 g protein**, **116.63 mg calcium**, **7.18 mg iron**, and **1.72 mg zinc** per serving.

The nutritious composition of the product is depicted in the figure 3.

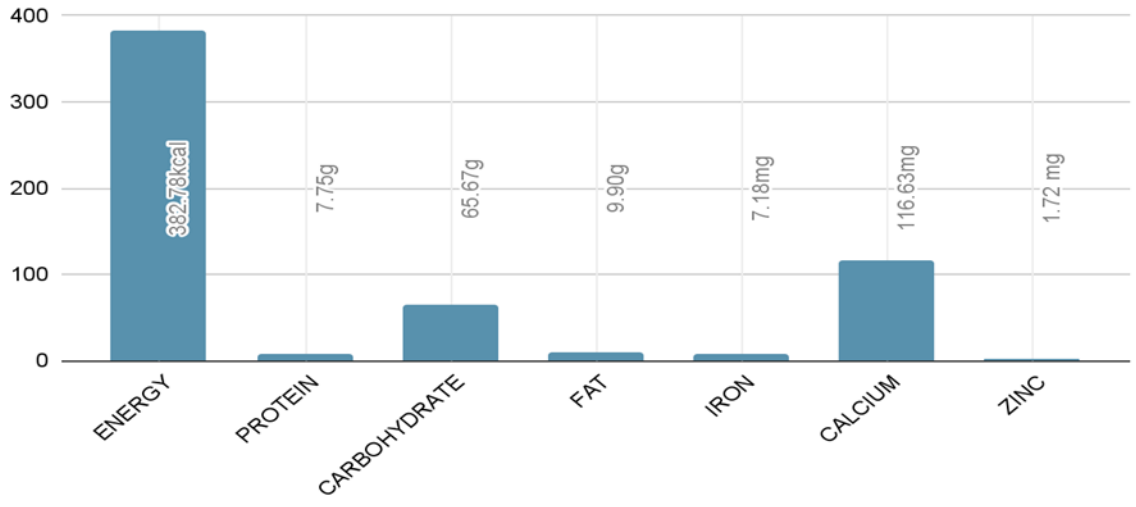

Fig 3. Nutrient composition of the developed product

Microbial analysis showed that the total bacterial count began at **450 CFU/g on Day 1,** increased to **3000 CFU/g in Week 1,** and reached **17727 CFU/g by Week 6**. The low initial microbial load and minimal coliform growth (less than 10 CFU/g across the six-week analysis) suggest that the product was formulated and handled in a sanitary environment. During the first several weeks, the amounts of bacteria remained within safe limits for eating, despite a rise over time. According to this outcome, the food has a respectable shelf life of between four to six weeks when stored normally, which is on par with or even better than many regular snacks that contain minimal preservatives.

3.3 Statistical Analysis

The mean and standard deviation of trials 1,2, and 3 are given in table 3.

Table 3. Mean & Standard deviation value of the products

Criteria	Black rice and chickpea Ladoo Trail-1	Black rice and chickpea Ladoo Trail-2	Black rice and chickpea Ladoo Trail-3
Taste	6.51 ± 1.49	7.37 ± 0.96	7.10 ± 1.82
Colour	7.17 ± 0.94	7.20 ± 0.88	7.51 ± 1.22
Appearance	7.24 ± 1.03	7.17 ± 0.94	7.37 ± 1.34
Texture	6.65 ± 1.49	7.06 ± 1.17	7.24 ± 1.61
Flavour	6.62 ± 1.49	7.20 ± 0.96	7.24 ± 1.50
Overall acceptability	6.68 ± 1.44	7.44 ± 1.00	7.62 ± 1.37

The analysis using mean and standard deviation indicated that among the three trials, **Trial 3** consistently had the highest acceptability score. This result is consistent with the trial's enhanced palatability and texture-flavor balance, which were probably brought about by the ideal component ratio. Much of the research that has already been done has concentrated on single components or recipes with less nutritional diversity than state-of-the-art methods. This study was able to provide a product with an improved macronutrient and micronutrient composition by combining black rice and chickpeas, which improved the product's flavor and nutritional value.

4 Discussion

The **paired T-test** results showed a **P-value of 0.071**, which is higher than the significance threshold of 0.05, indicating there is no statistically significant difference between the nutrient values of the raw and cooked products. In particular, there is no modest reduction in several micronutrients (likely due to heat degradation) was in line with results from related research, even though cooking had no discernible effect on the amounts of other advantageous phytochemicals. However, the amount of nutrients retained was greater than expected, most likely due to the cooking method that minimizes nutritional loss. This study showed higher nutritional retention than previously published data, which often show significant nutrient content losses after cooking. The careful regulation of black rice's cooking temperature and duration explains this, maintaining the integrity of heat-sensitive compounds like vitamins and particular polyphenols.

Montoya et al investigated black rice, Due to the presence of bioactive molecules, food items made with black rice may exhibit bioactivity with positive health benefits, hence increasing their nutritious value. Because bioactive compounds in black rice food items have antioxidant, antihypertensive, antidiabetic, anticancer, anti-obesity, and cholesterol-lowering properties, their functioning is linked to lowering the risk of several chronic illnesses.[11]

Table 4. Nutrient value before and after cooking - Black rice and chickpea ladoo

Black rice and chickpea ladoo	Before cooking	After cooking	T-value	df	P value
Energy (Kcal)	309.82 kcal	382.78 kcal			
Protein (g)	4.8904g	7.75g			
Carbohydrates (g)	17.2163g	65.67g			
Fat (g)	2.967g	9.90g	2.19	6	0.071
Calcium (mg)	92.429mg	116.63mg			
Iron (mg)	1.3504mg	7.18 mg			
Zinc (mg)	1.82mg	1.72mg			

Table 4 shows that per 100g of ladoo, Iron mg is 7.18mg when compared to Hymie et al the iron content is equally higher in amount. Same as calories and calcium content in this product.[12]

The cost of the Black Rice and Chickpea ladoo was calculated to be **₹70** per serving, including raw materials and overhead charges. This price is reasonable given that nutrient-dense products like chickpeas and black rice, whose health advantages are becoming more widely acknowledged, are used. This product offers a price-effective, functional food choice for people trying to control their weight or find better substitutes for traditional desserts or snacks, which are frequently high in calories but low in nutrients.[13]

The study's development is how it combines two nutrient-dense foods black rice and chickpeas to create a healthy snack that addresses obesity and malnutrition. Black rice, high in fiber and antioxidants, helps to regulate blood sugar, promote heart health, and help people control their weight.[14] Chickpeas are a good source of protein, fiber, and important minerals that help

with digestion and satiety. This product offers a healthy alternative to traditional ladoos, which are sometimes heavy in fat and sugar, without sacrificing flavor or texture.[15]

The understanding of how to make functional meals to maximize both nutrition as well as sensory appeal is expanded by this study. Conventional snacks are generally low in nutrients and high in calories, which increases the risk of non-communicable diseases (NCDs) including diabetes and obesity.[16] A healthier alternative that offers long-term health advantages without compromising flavor is black rice and chickpea ladoo. Crucially, the investigation showed that the food retained healthy ingredients like antioxidants and resveratrol after cooking, indicating a high level of nutrient retention. This has numerous benefits compared to conventional heat-processed snacks, which frequently lose their nutritious content. Black rice is minimal in sugar, salt, and fat and is gluten and cholesterol-free. Essential amino acids such as lysine and tryptophan, dietary fiber, functional lipids, vitamins B1, B2, and E, folic acid, and phenolic compounds (γ-oryzanols, tocopherols, and tocotrienols) are all found in black rice.[17] As long as the food stayed under safe microbiological limits, which guaranteed its safety and nutritional quality, its shelf life was acceptable for up to six weeks.

5 Conclusion

This study developed a functional food product that addresses key public health issues like malnutrition and obesity. The ladoo formulation utilized two highly nutritious yet underutilized ingredients, black rice and chickpeas to create a snack with enhanced nutritional value, appealing sensory characteristics, and shelf-life stability. The result shows a significant role in treating obesity and numerous health conditions with 382.78 kcal calories and 7.75g protein, 65.7g of CHO, 9.9g of fat, 7.18mg of Iron, 116.6mg of Cal, 1.72mg of zinc in it and further study is needed to investigate more properties in that product.

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