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Development and Nutritional Evaluation of Ready to Eat Grain Amaranth based Baked Products

T. N. Rachitha[1], S. Shamshad Begum[2], S. R. Anand[3] and K. G. Vijayalaxmi[4]
[1,2&4]Department of Food Science and Nutrition, College of Agriculture, UAS, GKVK, Bengaluru - 560 065
[3]AICRN on Potential Crops, University of Agricultural Sciences, GKVK, Bengaluru - 560 065
e-Mail : rachitha172@gmail.com

Authors Contribution

T. N. Rachitha :
Experimentation, data analysis and interpretation

S. Shamshad Begum :
Conceptualization, evaluation and supervision

S. R. Anand :
Resource provision, experimental facilitation and reviewing

K. G. Vijayalaxmi :
Methodology refinement, evaluation and guidance

Corresponding Author :
T. N. Rachitha

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Abstract

Grain amaranth (*Amaranthus hypochondriacus* L.), an ancient pseudo cereal has attracted a lot attention due to its remarkable nutritional qualities which includes high-quality proteins and valuable bioactive compounds. In this study, ready to eat (RTE) baked products *viz.,* coconut cookies and salt biscuits were developed by substituting grain amaranth flour for refined wheat flour at levels of 25 per cent, 50 per cent, 75 per cent and 100 per cent. Improving the nutritional value of conventional baked goods was the primary objective while maintaining sensory acceptability. Sensory evaluation of the developed products was done using a 9-point hedonic scale to assess the sensory attributes. The results revealed that the maximum acceptance scores were obtained when 50 per cent of the refined wheat flour was replaced with the grain amaranth in both coconut cookies and salt biscuits, exhibiting an ideal harmony between flavour profile and nutritional enhancement. The nutritional composition of the products was significantly elevated by the addition of the grain amaranth with significant increase in protein, fibre, iron and calcium content. Specifically, the amount of protein in 100 g of 50 per cent grain amaranth substituted coconut cookies and salt biscuits was 7.76 g and 10.25 g, respectively. This study under scores the potential of grain amaranth to fortify the nutritional value of baked RTE snacks, providing a healthier alternative to conventional options while maintaining consumer acceptability. These results emphasize the significance of incorporating underutilized crops like grain amaranth into food product innovation to address global nutrition challenges and support food security initiatives.

Keywords : Grain amaranth, Ready to eat, Sensory evaluation, Nutrient composition

In recent years, the fast moving and changing lifestyle have also changed eating habits based largely on Ready to Eat (RTE) and convenient foods which resulted in boosting of food processing industry. The shift from home cooking to convenience has drastically changed our diet composition. Such foods are generally low in fibre, proteins, essential minerals and vitamins (Verma and Chawla, 2020). Ready to Eat (RTE) products, particularly baked goods, have gained popularity as a result of their convenience, shelf stability and versatility. However, traditional baked goods often fall short in terms of nutritional quality, as they are typically high in refined carbohydrates, saturated fats and low in essential nutrients. This has sparked interest in the development of healthier alternatives that can meet the expanding consumer trend for functional and nutrient-dense foods. One promising grain that has garnered attention in this regard is grain amaranth (*Amaranthus hypochondriacus* L.), an ancient pseudo cereal recognized for its outstanding nutritional benefits and functional attributes. However, its significance tends to be over shadowed by more widely consumed cereal grains. Amaranth is regarded as a drought-tolerant and climate-resilient crop due to its adaptability to diverse climatic conditions (Revanth *et al*., 2024) and has enormous potential to fight both malnutrition and climate change (Murthy and Kumar, 2017).

Grain amaranth is a pseudocereal valued for its remarkable nutritional qualities, including a high protein content (12-18%), well-balanced amino acid profile and substantial amounts of essential nutrients. Unlike many other grains, amaranth contains lysine (5.50 g/100 g of protein), an essential amino acid often deficient in cereals, making it an ideal protein source for both children and adults, especially in regions plagued by malnutrition and food insecurity. Additionally, it is rich in bioactive compounds, including polyphenols, flavonoids and squalene, which contribute to its antioxidant, anti-inflammatory and cardioprotective properties. These features markedly boost the nutritional efficacy of amaranth-based products and contribute to their functional benefits, making them appealing for health-conscious consumers.

Delving deeper into its nutritional profile, grain amaranth has an exceptionally high nutritive value of protein (13.27 g/100 g), total fat (5.56 g/100 g), dietary fiber (7.47 g/100 g), ash (3.05 g/100 g), carbohydrate (61.46 g/100 g), energy (356.22 kcal/100 g), calcium (162 mg/100 g), iron (8.02 mg /100 g) and total folate (24.65 µg /100 g) (Longvah *et al*., 2017). In the realm of whole grains, grain amaranth is an excellent substitute, since it is gluten-free, which meets the nutritional demands of people with celiac disease or gluten sensitivity. Being an excellent source of iron, the grain can help in circumventing iron. The increased level of folic acid also helps in increasing the blood haemoglobin level in human beings. Incorporating grain amaranth into RTE baked products presents an opportunity to enhance their nutritional value while catering to the increasing demand for healthier snack options. Moreover, the inclusion of grain amaranth in baked products aligns with the growing trend toward sustainability and the use of underutilized crops to improve global food security.

Hence, the present research concentrated on the development and evaluation of grain amaranth based RTE baked products with the aim of enhancing their nutritional value while maintaining sensory acceptability. The research examined the use of grain amaranth as a functional ingredient in baked products like coconut cookies and salt biscuits, offering insights into its effects on the nutritional and organoleptic attributes of the final products.

Material and Methods

The present research was conducted in the Department of Food Science and Nutrition at University of Agricultural Sciences, GKVK, Bengaluru, India during the academic year 2023-2024.

Procurement of Raw Materials

Grain amaranth variety Suvarna was procured for the research from AICRN on Potential Crops, UAS, GKVK, Bengaluru and other ingredients were procured from local market, Bengaluru. The grain amaranth was thoroughly cleaned and then pulverized to fine flour which was subsequently utilized for the research.

Development of RTE Grain Amaranth Baked Products

The RTE grain amaranth baked products, namely coconut cookies and salt biscuits were developed by incorporating grain amaranth flour at substitution levels of 25 per cent, 50 per cent, 75 per cent and 100 per cent for refined wheat flour, while keeping all other ingredients constant across variations. The control samples were prepared entirely with refined wheat flour. The standardized protocol for preparing both RTE grain amaranth coconut cookies and salt biscuits is illustrated in Fig. 1.

For coconut cookies, the fat was creamed slightly before adding grain amaranth flour, refined wheat flour, icing sugar, desiccated coconut powder, granulated sugar and cardamom powder. The dough was kneaded to a soft consistency, divided into small round balls, and arranged on a baking tray. Each cookie was topped with cherry pieces and gently pressed before baking at 160°C for 20 to 25 minutes.

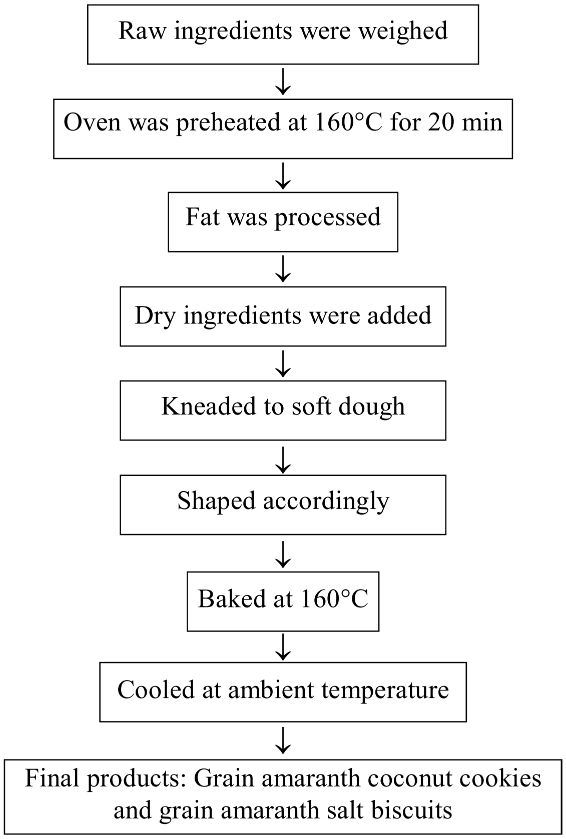


Fig. 1 : Standardized process flow for RTE grain amaranth baked products

For salt biscuits, the fat was rubbed with flour before incorporating sugar, milk powder, salt, cumin seeds, and carom seeds. The dough was kneaded to a soft consistency, rolled out to ¼" thickness, cut into desired shapes and forked. The biscuits were then baked at 160°C for 15 to 20 minutes.

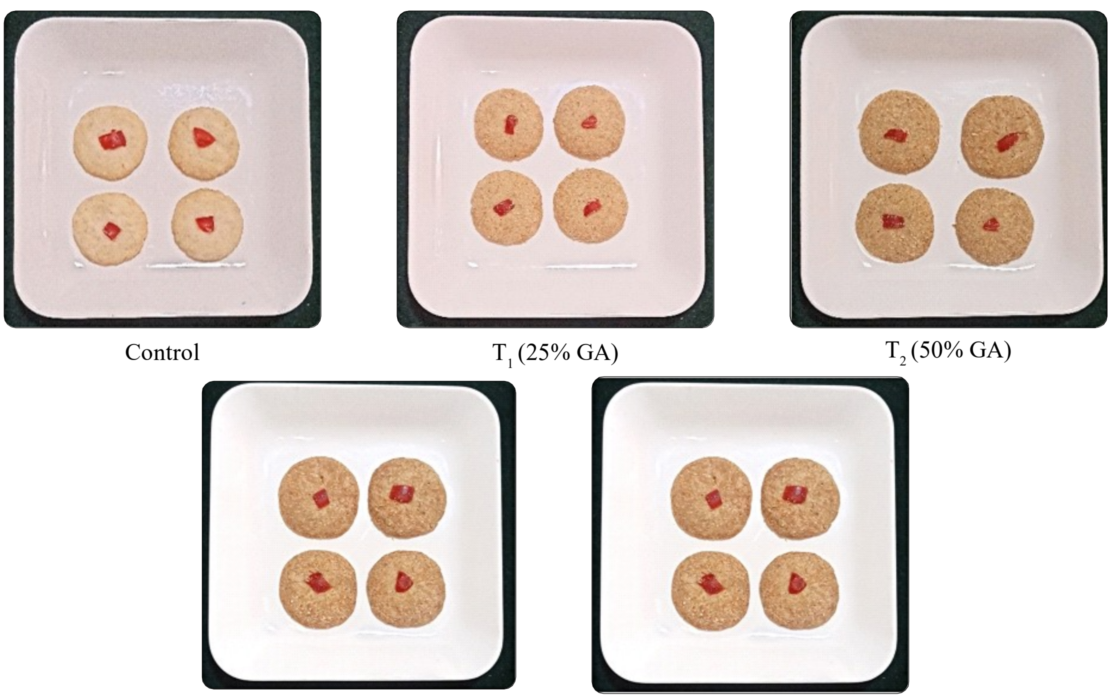
After baking, both products were cooled at ambient temperature before further analysis. The standardized protocol for preparing both RTE grain amaranth coconut cookies and salt biscuits is outlined below.

Sensory Evaluation of Developed Products

The developed products were organoleptically evaluated using 9-point hedonic scale (Ranganna, 1986) by 25 trained panel members. The products were assessed using a pre-structured and validated score sheet to evaluate sensory attributes such as appearance, colour, texture, taste, flavour and overall acceptability. The acceptability index was also calculated.

Nutrient Composition of Best Accepted RTE Grain Amaranth Baked Products

Nutrient composition of the best accepted developed products was analysed using standard protocols



Control T_1 (25% GA) T_2 (50% GA)

T_3 (75% GA) T_4 (100% GA)

Plate 1 : RTE grain amaranth coconut cookies

Control

T_1 (25% GA)

T_2 (50% GA)

T_3 (75% GA)

T_4 (100% GA)

Plate 2 : RTE grain amaranth salt biscuits

(AOAC, 2005). Analysis was carried out for the nutrients *viz.,* moisture, protein, fat, crude fiber, minerals. Carbohydrate was determined using difference method and energy was computed.

Statistical Analysis

Means of triplicates of the research data obtained were assessed using Complete Randomized Design (CRD) with the help of Microsoft excel (2010) and OPStat (14.139.252) software. One-way analysis of variance (ANOVA) was employed to analyse the sensory scores to determine the significant differences between the various characteristics and treatments of the developed products ($p< 0.05$) (Baljeet *et al*., 2010).

Results and Discussion

Mean Sensory Scores of RTE Grain Amaranth Baked Products

The mean sensory scores of grain amaranth coconut cookies are provided in Table 1 and Fig. 2. Among the four variations tested, T_2 (50% grain amaranth) achieved the highest mean sensory scores for all attributes. The acceptability index also highlighted T_2 as the most favoured variation. A noticeable reduction in sensory scores was observed across various attributes, including overall acceptability with an increase in the proportion of grain amaranth in the formulations. The 50 per cent incorporation level (T_2) seemed to strike the optimal proportionate of refined wheat flour and grain amaranth as the subtle, mildly nutty flavour of grain amaranth complemented the neutral flavour of refined wheat flour, contributing to a harmonious and enjoyable taste profile. Statistical analysis revealed a pronounced difference ($p < 0.05$) among the treatments for all sensory attributes.

A study by Sindhuja *et al.* (2005) explored the development of cookies with amaranth flour substituted at different concentrations (0, 10, 20, 25, 30 and 35%). It was observed that the cookies became more tender with increasing amaranth flour content and the 25 per cent substitution level was the most acceptable. In comparison, the present study achieved good sensory outcomes even at a higher substitution level of 50 per cent, suggesting better integration of grain amaranth in coconut cookies compared to the earlier findings by Sindhuja *et al.* (2005).

TABLE 1

Mean sensory scores of RTE grain amaranth coconut cookies

Treatment	Variations: Refined wheat flour (%)	Variations: Grain amaranth (%)	Appearance	Texture	Colour	Flavour	Taste	OAA	AI (%)
C	100	0	8.48 ± 0.82	8.40 ± 0.76	8.56 ± 0.76	8.48 ± 0.77	8.44 ± 0.82	8.52 ± 0.65	94.66
T_1	75	25	8.32 ± 0.85	7.84 ± 0.89	7.98 ± 1.03	8.00 ± 0.95	8.08 ± 0.81	8.12 ± 0.78	90.22
T_2	50	50	8.26 ± 0.57	7.92 ± 0.64	7.72 ± 0.79	8.20 ± 0.64	8.00 ± 0.86	8.16 ± 0.68	90.66
T_3	25	75	7.72 ± 0.79	7.72 ±0.61	7.52 ± 0.50	7.76 ± 0.92	7.64 ± 0.90	7.56 ± 0.82	84.00
T_4	0	100	7.64 ± 0.63	7.24 ± 0.66	7.24 ± 0.66	7.12 ± 0.66	7.00 ± 0.64	7.08 ± 0.70	78.66
F value			*	*	*	*	*	*	
CD			0.41	0.40	0.43	0.45	0.45	0.41	
SEm±			0.14	0.14	0.15	0.16	0.16	0.14	

Note : *-p<0.05, NS- Non significant, C- Control, OAA- Overall acceptability, AI- Acceptability Index

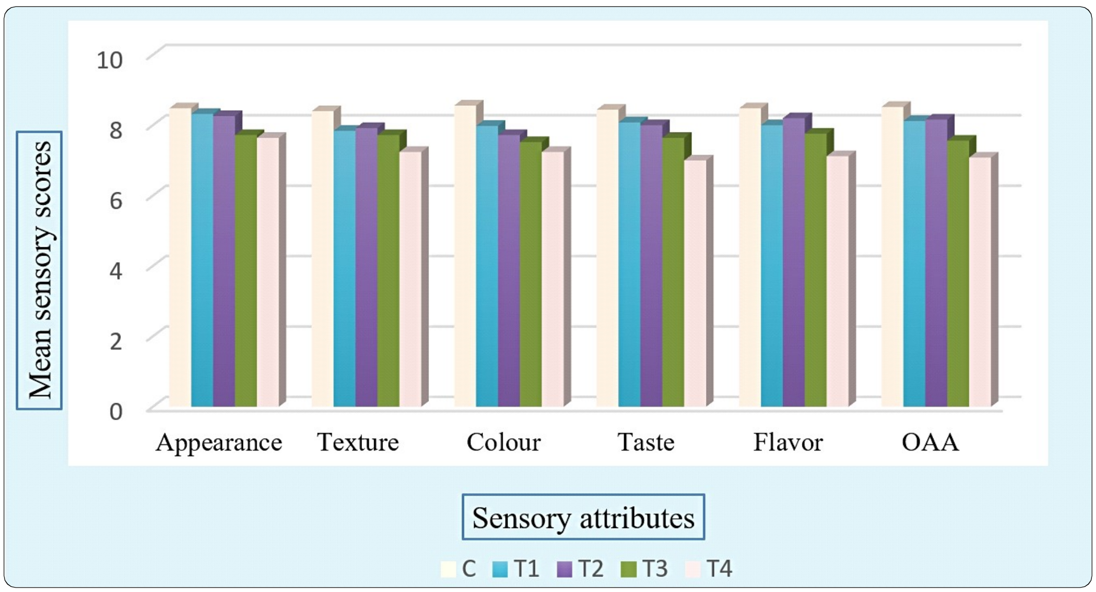


Fig. 2 : Mean sensory scores of RTE grain amaranth coconut cookies

Similarly, the sensory attributes of grain amaranth salt biscuits are summarized in Table 2 and Fig. 3. Statistical analysis showed a significant difference ($p < 0.05$) among the treatments for all sensory traits. Among the variations tested, the T_2 formulation (50% grain amaranth) demonstrated the highest overall acceptability, indicating superior sensory attributes at this ratio. Sensory scores steadily declined as the proportion of grain amaranth increased from 25 per cent to 100 per cent. However, the T_2 formulation (50% grain amaranth) maintained favourable sensory attributes, providing an ideal balance between the nutty taste of grain amaranth and the mild, light flavour of refined wheat flour. This led to a harmonious and appealing flavour in the salt biscuits. Similar out comes were noted by Annapurna *et al.* (2001), where a 50 per cent substitution of grain amaranth was determined to be well acceptable in baked items.

TABLE 2

Mean sensory scores of RTE grain amaranth salt biscuits

Treatment	Variations: Refined wheat flour (%)	Variations: Grain amaranth (%)	Appearance	Texture	Colour	Flavour	Taste	OAA	AI (%)
C	100	0	8.16 ± 0.68	7.96 ± 0.53	8.28 ± 0.89	8.12 ± 0.72	8.28 ± 0.83	8.12 ± 0.69	90.22
T_1	75	25	8.40 ± 0.50	8.28 ± 0.54	8.16 ± 0.68	8.20 ± 0.86	8.20 ± 0.75	7.98 ± 0.84	88.66
T_2	50	50	7.80 ± 0.75	7.92 ± 0.62	7.76 ± 0.81	7.68 ± 1.06	7.76 ± 1.11	8.14 ± 0.65	90.44
T_3	25	75	7.72 ± 0.73	7.92 ± 0.49	7.88 ± 0.76	7.68 ± 0.65	7.44 ± 0.90	7.64 ± 0.68	84.88
T_4	0	100	7.40 ± 0.70	7.72 ± 0.73	7.32 ± 0.88	7.32 ± 0.69	7.40 ± 0.81	7.44 ± 0.79	82.66
	F value		*	*	*	*	*	*	
	CD		0.38	0.33	0.45	0.45	0.50	0.41	
	SEm±		0.13	0.11	0.16	0.16	0.17	0.14	

Note : *-p<0.05, NS- non significant, C- Control, OAA- Overall acceptability, AI- Acceptability Index

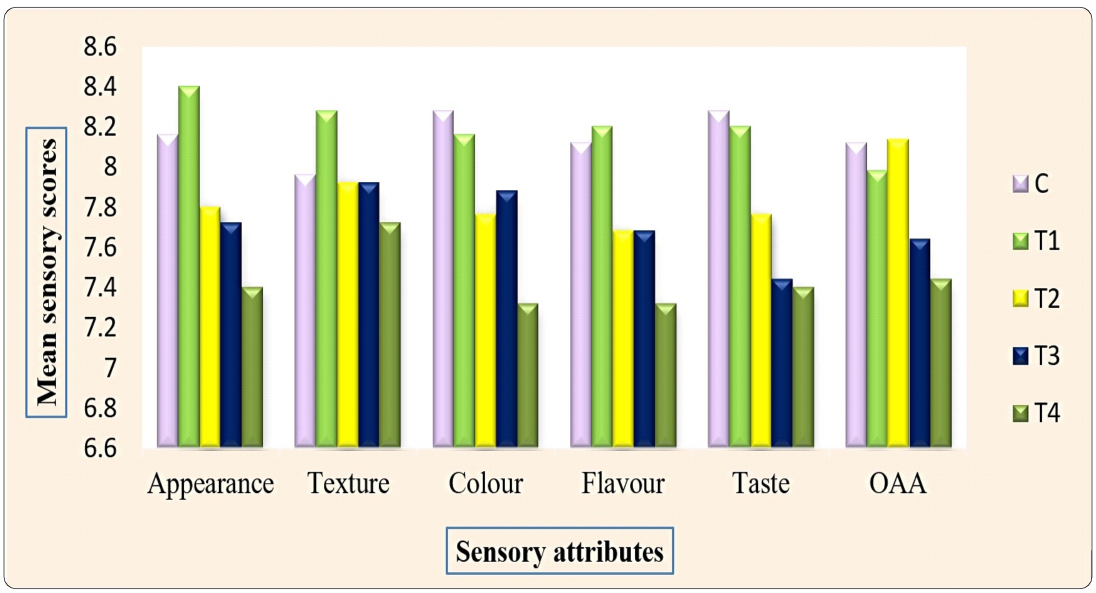


Fig. 3 : Mean sensory scores of RTE grain amaranth salt biscuits

Proximate Composition of Best Accepted RTE Grain Amaranth Baked Products

Data depicted in Table 3 indicates the nutritional composition of coconut cookies and salt biscuits with both control formulations and the best accepted variations having 50 per cent grain amaranth (GA). The moisture content of the control coconut cookies was 4.24 per cent, which decreased to 3.93 per cent in 50 per cent GA variation. Similarly, the moisture content of the control salt biscuits was 5.23 per cent, while the 50 per cent GA formulation had a lower value of 4.66 per cent. These decrease in moisture content is likely due to grain amaranth's lower moisture-holding capacity. The protein

TABLE 3

Proximate composition of best accepted RTE grain amaranth baked products (per 100g)

Products		Moisture (%)	Protein (g)	Fat (g)	Total ash (g)	Crude fibre(g)	*Carbohydrate (g)	**Energy (Kcal)
Coconut	Control	4.24	5.22	20.74	1.94	3.07	67.86	479
Cookies	50% GA	3.93	7.76	24.38	2.01	3.83	61.92	498
Salt Biscuits	Control	5.23	7.10	16.65	1.15	1.34	68.47	459
	50% GA	4.66	10.25	17.71	2.14	4.41	65.24	461

Note : GA- Grain amaranth; * By difference; ** By computation

content was found to increase with the inclusion of grain amaranth. The control coconut cookies contained 5.22 g of protein, whereas the 50 per cent GA formulation had a higher value of 7.76 g. Likewise, the protein content in the salt biscuits increased from 7.10 g in the control to 10.25 g in the 50 per cent GA formulation. Fat content also increased in both products with the addition of grain amaranth. The fat content of the coconut cookies increased from 20.74 g to 24.38 g, while for the salt biscuits, it increased from 16.65 g to 17.71 g. The total ash content of the coconut cookies slightly increased from 1.94 g in the control to 2.01 g in the 50 per cent GA variation. A more substantial increase was observed in the salt biscuits, where the ash content increased from 1.15 g in the control to 2.14 g in the 50 per cent GA formulation reflecting the higher mineral content of grain amaranth. The crude fiber content also improved with the addition of grain amaranth. The fiber content in the coconut cookies increased from 3.07 g to 3.83 g, while in the salt biscuits, it increased significantly from 1.34 g to 4.41 g. The carbohydrate content decreased with the inclusion of grain amaranth. The control coconut cookies had 67.86 g of carbohydrates, which dropped to 61.92 g in the 50 per cent GA version. The control salt biscuits had 68.47 g of carbohydrates, decreasing to 65.24 g in the 50 per cent GA formulation. The energy content showed a slight increase with the addition of grain amaranth. In coconut cookies the energy content increased from 479 Kcal to 498 Kcal, while in the salt biscuits, it increased slightly from 459 Kcal to 461 Kcal. Results were aligned with the study reported by Bhat *et al.* (2015) where nutritional analysis of value-added cookies developed from grain amaranth showed that cookies can act as a good source of protein (8.85%), carbohydrates (64.37%) and dietary fiber (3.88g) and hence a potential source of energy (434.72 Kcal).

Mineral Composition of Best Accepted RTE Grain Amaranth Baked Products

The mineral content of coconut cookies and salt biscuits with both control and 50 per cent grain amaranth (GA) is outlined in Table 4. Calcium content increased significantly in both products, rising from 8.74 mg to 36 mg in the coconut cookies and from 59.61 mg to 86.42 mg in the salt biscuits. This rise is attributed to the higher calcium content in grain amaranth. Copper content showed a small increase in both products, from 0.13 mg to 0.14 mg in the coconut cookies and from 0.13 mg to 0.23 mg in the salt biscuits. The iron content also showed a significant increase in coconut cookies from 0.58 mg to 2.35 mg, whereas in salt biscuits, it increased from 0.90 mg to 3.06 mg. This increase is due to grain amaranth's high iron content. Potassium levels saw an increase from 100.78 mg to 124.02 mg in the coconut cookies and from 155.28 mg to 214.54 mg in the salt biscuits, reflecting grain amaranth's richness in potassium. Magnesium content increased markedly, rising from 26.50 mg to 68.04 mg in the coconut cookies and from 29.36 mg to 93.33 mg in the salt biscuits, due to grain amaranth's high magnesium content. Manganese levels increased from 0.36 mg to 0.77 mg in the coconut cookies and from 0.76 mg to 0.83 mg in the salt biscuits, attributed to the higher manganese content in grain amaranth. Sodium content decreased slightly in the coconut cookies, from 3.38 mg to 2.39 mg, but remained nearly unchanged in the salt biscuits.

TABLE 4

Mineral composition of best accepted RTE grain amaranth baked products (per 100g)

Products		Calcium (mg)	Copper (mg)	Iron (mg)	Potassium (mg)	Magnesium (mg)	Manganese (mg)	Sodium (mg)
Coconut	Control	8.74	0.13	0.58	100.78	26.50	0.36	3.38
Cookies	50% GA	36.00	0.14	2.35	124.02	68.04	0.77	2.39
Salt Biscuits	Control	59.61	0.13	0.90	155.28	29.36	0.76	598.88
	50% GA	86.42	0.23	3.06	214.54	93.33	0.83	599.50

The minimal change in sodium is possibly attributed by the formulation's reliance on other ingredients for sodium content, as grain amaranth is not particularly high in sodium.

The development Ready to Eat (RTE) grain amaranth based baked products with improved sensory and nutritional qualities offers a convenient and nutritious snack alternative, particularly for populations requiring energy-dense and protein-rich foods. This study demonstrated that incorporating grain amaranth into coconut cookies and salt biscuits significantly increased their protein content from 5.22 g to 7.76 g in coconut cookies and 7.10 g to 10.25 g in salt biscuits while also enhancing their mineral profile such as calcium, iron, magnesium and potassium. Among the variations, the 50 per cent grain amaranth formulation (T_2) secured the highest overall acceptability, striking an ideal balance between sensory appeal and nutritional enhancement. Sensory evaluation unveiled a gradual fall in scores as the grain amaranth proportion increased, indicating that a 50:50 ratio is optimal for both taste and nutrition. By partially replacing refined wheat flour with grain amaranth, these products deliver superior nutritional value with good protein and fibre content while retaining desirable sensory properties, presenting a healthier alternative for consumers and contributing to improved dietary options.

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