"DEVELOPMENT OF MULTIGRAIN COOKIES: PHYSICOCHEMICAL ATTRIBUTES, NUTRITIONAL VALUE AND SENSORY ANALYSIS"

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Abstract:

Background: Multigrain Cookies are made up of cereals which is the main source of energy and provide numerous nutritional benefits. It is one of the best-known snack options and can enhance its nutritional values by adding with other nutrient rich ingredients. Hence this study aimed to investigate the sensory characteristics, physicochemical attributes, nutritional value of multigrain cookies. **Methodology**: The cookies were formulated with varying proportions of multigrain flour like ragi flour, wheat flour and chia seeds (20:5:7) Multigrain Cookies 1 (MGC1), (5:20:7) Multigrain Cookies 2 (MGC2) and refined flour and milk powder were used in control cookies (CC). Sensory evaluation was performed with 20 semi trained panel members to measure attributes such as appearance, aroma, taste, texture, and overall acceptability of the nutrient enhanced cookies against control. Physical and functional properties were analysed included measurements of cookie diameter, thickness, spread ratio, and water & oil absorption. Additionally, proximate analysis was conducted to assess the nutritional composition, focusing on macronutrients and micronutrients such as protein, fat, carbohydrates, dietary fiber, and minerals. **Results**: Obtained results suggested that overall acceptability of both the MGC 1 & 2 were high than control sample (8.24±0.72, 7.59±0.87 & 8.27±0.63). Incorporation of multigrain flour and chia seeds influenced the physicochemical properties of the cookies, altering their texture and appearance. Furthermore, proximate analysis result revealed that MGC1 was containing Ash (3g/100g), Moisture (5.6g/100g) Carbohydrate (68.9g/100g), Protein (8.2g/100g), Dietary fiber (11.3g/100g), Calcium (243.04mg/100g). **Conclusion**: This study indicates that cookies made with multigrain like wheat flour, ragi flour, and chia seeds, are high in macronutrients and minerals, offering numerous health benefits.

Key Words: Multigrain, macronutrients, acceptability, enriched, chia seeds.

I. Introduction:

Developing nutrient dense food product is essential to manage the food security, preventing the chronic diseases, reducing the cases of specific nutrient deficiencies and targeting the community-based population for overall wellbeing, especially in developing countries. Considering this, many researchers and food technologist coming up with new concepts for developing the nutrient rich and high-quality food products with staple and locally available raw ingredients. Because of lifestyle changes, busy schedules, improper diet and food consumption people are looking for functional foods, nutrient enriched and ready to eat foods to maintain their health in good

terms. It is also necessary to overcome the diseases like, diabetes, obesity, hormonal changes, cardiovascular diseases etc (Hamrick 2021). Nowadays, Baked products are like cookies, pastries, cake, breads are common eatables as a snack among all the age group. Mainly, Cookies are more popular throughout the world as they are palatable, easily available, inexpensive, has good storage stability and convenient for consuming and provide more nutrients than any other single sources. As cookies are having less moisture content compare to other baked products it can be develop in bulk and store for several days. Cookies are crispy in texture and also known as flat cake. It can be fortified or incorporated with unsaturated fat, high fiber, complex carbohydrates rich foods ca and bioactive compounds to enhance the nutritional value in human diet (Abiyot Negu 2020) (Feriehiwote Weldeyohanis Gebremariam 2024).

Finger millet is also called as ragi which is a staple food in the south India, predominantly in Karnataka. Ragi usually ranks third in cereal production in semi-arid regions of the globe, after sorghum and pearl millet (Bellundagi 2016). It has rich nutrient profile with good quality of protein with abundant number of amino acids, complex carbohydrate in the form polysaccharides, fibre. It is also rich in calcium, phosphorus, iron and also it is rich in iodine than any other grains. As ragi is primary source of food, it can be used in many health conditions to control them. It can be controlling the blood glucose level, reduces the cholesterol level, bone health, reduces the appetite and may help in weight loss. It is also good for anemia, and preventing the nutrient deficiencies. It is good source for children, pregnant women, adults and senior population (Florence 2014).

One more main ingredient used was whole wheat flour (*Triticum aestivum L*), again it is very important and one of the staple foods in the India and globally too. Whole wheat flour and refined wheat flour have been used for milling and baking but mainly refined flour is used more. But it doesn't have enough fiber as bran and germ are removed and only starchy endosperm has been left. Refined flour is completely starch flour which commonly used for baking. Products outcome would be soft and palatable as the refined flour have used, but it increases the blood glucose level when consumed because of the fibre deficiencies. Hence whole wheat flour can be replaced refined flour, for preparing the baked products. It contains carbohydrate 78.10%, protein 14.70%, fat 2.10%, minerals 2.10% and considerable proportions of vitamins (thiamine and vitamin-B) and minerals (zinc, iron). Several health benefits are existing in the whole wheat grain. It helps in optimizing the glucose level, protect against the heart disease with the help antioxidants, vitamins and phytochemicals, firbes present in it. Apart from metabolic syndromes it also fights as an anti-cancerous agent. Fibre and particular starches present in the whole wheat ferment in the colon and block the bile acids which emanates the cancer agent as well as researched proves that lower the risk of hormone related cancers (Kumar 2011) (Biradar 2021).

Chia seeds (*Salvia hispanica L)* is considered as pseudo cereal which belongs to family called Lamiaceae. As It is filled abundant nutrients nowadays it has been incorporating in most of the healthy foods. It has protein, high fibre, vitamins, minerals and mainly with healthy fats. Around 25-40% of fat content is there which consists of 68% of omega 3 fatty acids and 20% of omega 6 fatty acids (Agarwal 2023). It is also containing good amount amino acid profile especially lysine, leucine, isoleucine and valine. Apart from major nutrients chia seed is rich in bioactive components like phenolic compounds, phytoesterols. Consuming recommended amount of chia seeds helps to improve the digestive system, reduces the cardiovascular disorder conditions, reduces the blood cholesterol and glucose level (Khalid 2022).

II.   Materials and Methodology:

As mentioned in table 1, all the ingredients Refined flour, Wheat flour, Ragi flour, Milk powder, Chia seeds, Lemon zest, Coconut oil, Palm sugar, baking soda, Salt were purchased from the local super market in Mysore.

Table1: Composition of cookies

INGREDIENTS	SC	MGC 1	MDC 2
Refined flour	42g	-	-
Wheat flour	-	10g	40g
Rgai flour	-	40g	10g
Milk powder	17g	-	-

Chia seeds	-	14g	14g
Lemon zest	-	1g	1g
Coconut oil	8ml	10ml	10ml
Palm sugar	20g	24g	24g
Baking soda	0.5g	0.5g	0.5g
Salt	0.5g	0.5g	0.5g

Preparation of cookies

Allow the oven to preheat for ten minutes at 180 degree celsius. In a bowl, coconut oil and palm jaggery were added, whisked well until a smooth creamy texture as obtained. Followed by lemon zest, baking soda and pinch of salt were added. Along with these, for control product refined flour and milk powder were added. For variation cookies Ground the chia seeds into grids and added with lemon zest, baking soda and pinch of salt and mix well. Into the mixture, added wheat flour and ragi flour and kneaded until a smooth dough was obtained. Dough was made into cookies shape and baked at 180^0C for 15mins. After cooling, cookies were packed in foil envelops, labelled and stored at ambient temperature for various determinations.

Fig1a: Control Cookies (SC)	**Fig1b: Multigrain Cookies (MGC1)**	**Fig1c: Multigrain Cookies (MGC2)**

Sensory evaluation: A 9-point hedonic scale and qualitative descriptive profile analysis methodologies were used by 20 semi-trained panelists to assess the prepared food sensory. The assessment was carried out to evaluate a number of quality criteria, including acceptance overall, taste, texture, and appearance and color. To rinse the mouth between assessments, water at room temperature was available. Each attribute received a distinct 9-point score as well as a rating on a range of 1 to 9 (Yeh et al 1998).

Chemical composition: The moisture, Ash, protein, fat, dietary fibre were analysed by AOAC procedures. The carbohydrate content was calculated by the diff erence method [100- (%moisture+% crude protein + % Crude fat+ %ash + % fi ber). Energy content was calculated by multiplying protein, fat and carbohydrate contents by factors of 4, 9 and 4, respectively. The minerals like calcium and iron were determined by Atomic Absorption Spectrometer as per the method of Semwal et al. (1995). The mean of three independent determinations was reported.

Physical and functional characteristics: The diameter (D) and thickness (T) in mm of biscuit were measured using Vernier callipers and spread ratio (D/T) of biscuit was calculated. The weight of the cookies was also noted. The mean of three independent determinations have been reported as described earlier. Adeleke and Odedeji's (2010) approach was used to calculate bulk density. Water absorption capacity and Oil absorption capacity were analysed by using Bala A 2020 procedure.

Statistical analysis: All the experiments were carried out in triplicates and standard deviation of the results was calculated using Excel -2011
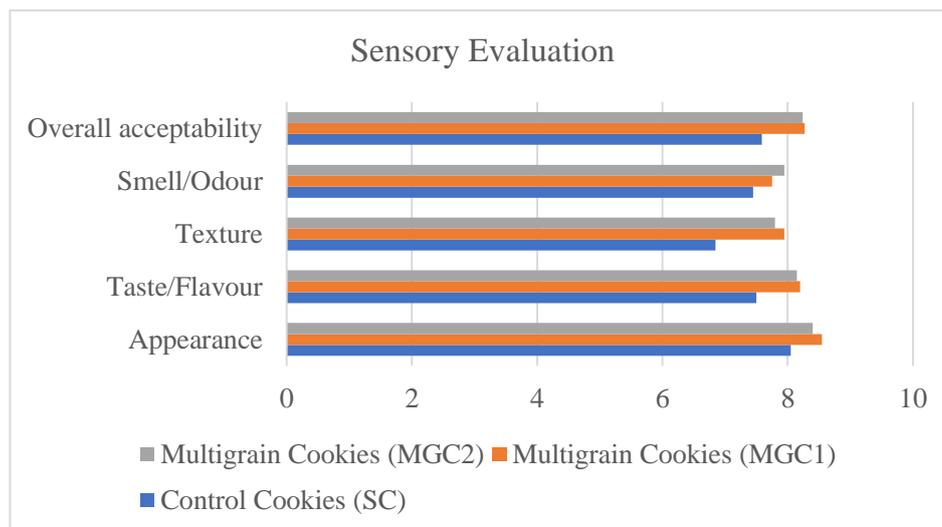
III.   Results & Discussion

Fig 2: Sensory score for the attributes of the developed cookies samples

Figure 2 shown that among all three variations of sensory attributes, MGC2 cookie has highly accepted than MGC1 and standard cookies. It is because of high amount wheat was added than ragi as it gives soft texture. Similar result was found in the study by (Shital Jamale 2022) where increasing ragi had reduced the overall acceptability of product.

Table 2: Physical and functional properties of cookies

Properties	Control Cookies (CC)	MGC 1	MGC 2
Cookie diameter (mm)	57.5	56	56.5
Cookie thickness (mm)	16.66	15.23	19.3
Cookie spread ratio	3.451	3.67	2.922
Bulk density (g/ml)	0.588	0.625	0.6
Water absorption capacity (ml/g)	88.51	92.43	88.36
Oil absorption capacity (ml/g)	112.22	106.29	112.39

Table 2 suggested physical and functional properties of cookies. Results found that cookies diameter and thickness of MGC1 & MGC2. MGC1 was having high thickness than MGC2. This might be high fibre and protein content absorbs the water, don't allow to spread during the baking and reduced the diameter and thickness of cookies. Many studies have shown the similar results where the ingredients like ragi and chiaseeds absorbs the water and limit the cookies diameter (Yamsaengsung & Berghofer (2010). Spread ratio was highest in MGC1 compared to MGC2, due to the slightly increase in fibre which strengthens the dough and limit the spreading ratio during the baking. Because of fibre content in the added grains flours reduced the thickening of the cookies (Kurek et al. (2017). Water absorption capacity was high in MGC1 than the other variations. Because, ingredients added in the MGC1 cookies were containing high amount of fibre which binds the water more. It was also found the study by (Kaur & Singh 2005).

Table 3: Nutritional analysis of cookies-100gm

Parameters	Standard	Variation 1	Variation 2
Energy (kcal)	428.5	391.2	385.1
Carbohydrate %	66.2	68.9	69.1
Protein %	10.5	8.2	7.1
Fat %	13.7	10.2	10.1
Dietary fiber g/g	1.4	11.3	11.6
Moisture %	4.9	5.7	5.8
Ash %	2.3	3	2.9

Data of proximate profile have been mentioned in the table 3, there was decrease in total energy in both the variations than standard cookies. Carbohydrate content have increased in both MGC1(68.9g) & MGC2 (69.1g), this might be increasing in the complex carbohydrate from the whole grain which contributed to increase the content. Protein content was reduced in both variations MGC1 (8.2g) and MDC2 (7.1g) as substituted milk powder with whole grains. This contributes to increase the fibre and complex carbohydrate. A study found that incorporating the plant-based ingredients often reduces the protein percentage (Moyo, Helen 2024). Fat content of variations had increased where chia seed contributed in increasing the fat percentage which also contain omega 3 fatty acids. There was a significance increase in dietary fibre as both the variations (MGC1 11.3g & MGC2 11.6) were incorporated with high fibre content than CC which was prepared by refined flour (Ngo HBG 2024). Ash content was slightly increased in MGC2 which indicated due to the nutrient dense ingredients. A study found out that adding chia seeds increases the mineral like calcium, iron and zinc which is also a contribute to increasing the ash in food products (Coorey 2014).

Table 4: Estimation of mineral contents

Parameters/ mg/100g	Control Cookies	MGC1	MGC2
Calcium	189.68	243.04	148.84
Iron	0.68	2.84	2.99

As per table 4, suggested that significantly higher in calcium was observed in MGC1 than MGC2 as ragi was incorporated in large amount. Iron content of two variations of cookies varied from 2.84-3.82 mg/100g.

Conclusion

This study concludes that, multigrain cookies were formulated with incorporating whole wheat flour, ragi flour and chia seeds in different variations with control cookies. In sensory evaluation, MGC2 was accepted than other two variations. Physicochemical analysis revealed differences in cookie diameter, thickness, spread ratio, water and oil absorption capacities, and bulk density across the varieties. As ragi and whole wheat flour are rich source of calcium and iron their utilization significantly improved the iron and calcium content of cookies. Hence the utilization of ragi in cookies will helps to improve the nutritional status of consumer.

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