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Development of Chia Seeds Biscuits: Effect of Different Flours on Sensory Attributes and Nutritional Value

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ABSTRACT

The study aimed at development of chia seeds biscuits using different cereal and millet flours. Total seven biscuits varieties were prepared using cereal and millet flours namely refined wheat flour, whole wheat flour, makhana flour, jowar flour, bajra flour, maize flour and ragi flour. Nutritive values of all biscuits were calculated using standard food composition tables. Cost of biscuits was calculated. Sensory evaluation was carried out by six judges in three trials. Score cards with keys were prepared. All biscuits were well accepted for appearance, colour, texture, doneness, flavour, and taste. Chia seeds biscuits were found to be good in energy and macro-nutrients. Fiber content of these cereal/millet flour biscuits was also good. Also, these biscuits were good in micro-nutrient profile. It is concluded that different cereal and millets flours can be successfully used in making chia seeds biscuits without affecting the sensory quality.

Keywords: chia seeds, makhana, ragi, jowar, bajra, sensory evaluation

INTRODUCTION

Biscuits are one of the most popular bakery products globally, appreciated for their taste, convenience, and extended shelf life. However, there has been increasing consumer demand for healthier options, leading to innovations in functional biscuits enriched with nutrient-dense ingredients like chia seeds and different whole cereal and millet flours. Chia seeds (Salvia hispanica L.), native to Central and South America, are recognized as a superfood due to their high content of omega-3 fatty acids, dietary fiber, protein, and antioxidants (K. Divyashree, et al., 2016, Ojokoh et al., 2023; Goswami, K. and Awasthi, P., 2022). Their incorporation into bakery products offers a dual advantage of enhancing nutritional value while catering to the demand for functional foods (Dincoglu, A. H. and Yesildemir, O., 2019).

Chia seeds have been extensively studied for their potential to improve the nutritional profile of biscuits. Research indicates that replacing traditional refined wheat flour with chia seed powder or blending it with other flours enhances protein content, dietary fiber, and mineral levels in biscuits, making them a better choice for health-conscious consumers (Chellamboli, Chelladurai. et al., 2019). The presence of bioactive compounds such as phenolics and flavonoids also contributes to their antioxidant capacity, which further amplifies their health benefits (Research Square, 2024).

Additionally, chia seeds influence the physical and sensory properties of biscuits. Studies report that the inclusion of chia seed powder can increase dough viscosity, leading to changes in texture, crispiness, and overall appearance. Optimal incorporation levels have been identified to strike

a balance between enhanced nutritional value and sensory acceptability, as excessive chia content might negatively impact taste and texture (Grancieri, M. et al., 2019).

The use of composite flours in biscuit production, combining chia seeds with other flours like wheat, jowar, bajra, maize etc. is good idea. These formulations can further diversify the nutritional attributes, particularly in terms of amino acid balance and energy value (Hassan, Heba. M. M. et al., 2023 and Ojokoh et al., 2023). Moreover, the development of such products aligns with the broader goal of promoting sustainable and nutrient-rich alternatives in food systems (Jan, Tabeen. et al., 2022).

This study aims to evaluate the impact of incorporating chia seeds and different cereal and millet flours on the sensory attributes and nutritional value of biscuits. By examining these parameters, the research seeks to optimize formulations that cater to both health benefits and consumer preferences.

METHODOLOGY

This research was undertaken to prepare chia seeds biscuits using different flours. Total seven biscuits varieties were prepared. Controlchia seeds biscuits were prepared using refined wheat flour. Experimental chia seeds biscuits were prepared by replacing refined wheat flour with other flours as shown below-----

- Chia seeds refined wheat flour biscuits (Control/C)
- Chia seeds wheat flour biscuits (Experimental-1/E1)
- Chia seeds makhana flour biscuits (Experimental-2/E2)
- Chia seeds jowar flour biscuits (Experimental-3/E3)
- Chia seeds bajra flour biscuits (Experimental-4/E4)
- Chia seeds maize flour biscuits (Experimental-5/E5)
- Chia seeds ragi flour biscuits (Experimental-6/E6)

Table 1: Composition of Control and Experimental Biscuits

Sr. No.	INGREDIENTS	QUANTITY (g)						
		C	E1	E2	E3	E4	E5	E6
1	Chia Seeds	15	15	15	15	15	15	15
2	Flour	35 (Refined Wheat Flour)	35 (Wheat Flour)	35 (Makhana Flour)	35 (Jowar Flour)	35 (Bajra Flour)	35 (Maize Flour)	35 (Ragi Flour)
3	Butter	25	25	25	25	25	25	25
4	Sugar	25	25	25	25	25	25	25
5	Milk Powder	20	20	20	20	20	20	20
6	Almond Powder	10	10	10	10	10	10	10
7	Cashew Nut Powder	15	15	15	15	15	15	15
8	Milk	5	5	5	5	5	5	5
9	Baking Powder	1.5	1.5	1.5	1.5	1.5	1.5	1.5
10	Vanilla Essence	2-3 drops	2-3 drops	2-3 drops	2-3 drops	2-3 drops	2-3 drops	2-3 drops

SENSORY EVALUATION:

Sensory evaluation of all control and experimental biscuits was conducted in 3 trials by 6 judges. Control and experimental biscuits were coded and presented to judges with score cards and keys.

Table 2: Score Card for Control and Experimental Biscuits

Biscuits	Appearance	Colour	Texture	Doneness	Flavour	Taste	Acceptability
C							
E1							
E2							
E3							
E4							
E5							
E6							

Table 3: Key for Control and Experimental Biscuits

Appearance	Colour	Texture	Doneness	Flavour	Taste	Taste	Acceptability	Scores
Very good	Very good	Very good	Very good	Very good	Very good	Very good	Well Acceptable	10
Good	Good	Good	Good	Good	Good	Good	Acceptable	8
Fair	Fair	Fair	Fair	Fair	Fair	Fair	Fairley Acceptable	6
Poor	Poor	Poor	Poor	Poor	Poor	Poor	Not Acceptable	4

CALCULATION OF NUTRITIVE VALUE OF BISCUITS:

Nutritive value of all control and experimental biscuits was calculated using standard Food Composition Tables (Longvah, T. et al., 2017).

CALCULATION OF COST OF BISCUITS:

Cost of all control and experimental biscuits was calculated based on current market price of ingredients.

STATISTICAL ANALYSIS:

Scores given by six judges in three trials were collected and tabulated. Comparisons between control and experimental biscuits was done using F test.

Null hypothesis: There is no real difference between control and experimental biscuits for their sensory characteristics (appearance, colour, texture, doneness, flavour, taste and acceptability) of if it is, it is just by chance.

PHOTOGRAPHS OF CHIA SEEDS BISCUITS

Photo I: Chia Seeds Refined Wheat Flour Biscuits (Control)

Photo II: Chia Seeds Whole Wheat Flour Biscuits (Experimental 1)

Photo III: Chia Seeds Makhana Flour Biscuits (Experimental 2)

Photo IV: Chia Seeds Jowar Flour Biscuits (Experimental 3)

Photo V: Chia Seeds Bajra Flour Biscuits (Experimental 4)

Photo VI: Chia Seeds Maize Flour Biscuits (Experimental 5)

Photo VII: Chia Seeds Ragi Flour Biscuits (Experimental 6)

RESULTS AND DISSCUSSION

BASIC DATA FOR BISCUITS:

Table 4: Basic Data for Biscuits

Parameters	Control Biscuits	Experimental Biscuits					
		E1	E2	E3	E4	E5	E6
Weight of dough (g)	69.28	63.71	74.28	63.14	67.57	65.71	63
Milk required (ml)	5	5	4	5	5	4	3
Kneading time (min : sec)	3:35	3:08	3:06	1:03	2:38	1:33	1:48
Baking time (min)	18	14	14	17	15	15	13
Baking temperature (^{0}C)	160	160	160	160	160	160	160
Total weight of all biscuits before baking (g)	146	136	168	146	165	132	138
Total weight of all baked biscuits (g)	133	125	155	123	152	121	117
Weight per biscuit before baking (mean) (g)	12.16	12.36	12.92	13.27	12.69	12	12.54
Weight per biscuit after baking (mean) (g)	11.08	11.36	11.92	11.18	11.69	11	10.63
Thickness per biscuit before baking (mean) (mm)	0.50	0.48	0.49	0.50	0.42	0.42	0.39
Thickness per baked biscuit (mean) (mm)	0.40	0.38	0.39	0.40	0.32	0.32	0.29
Total no. of biscuits	12	11	13	11	13	13	11

Table 4 presents basic data for control and experimental biscuits. Even though the quantity of flour and other ingredients were same for all type of biscuits there occurred variations in terms of requirement of milk and weight of dough which is clearly seen from table 4. Ragi flour biscuits required the lowest quantity of milk whereas jowar flour biscuits required lowest kneading time. Baking time also showed difference with ragi flour biscuits the minimum (13 min) jowar flour biscuits the maximum (17 min).

Chia seeds can affect the baking time and doneness of biscuits due to their moisture-absorbing

properties. They may contribute to a slightly longer baking time or require adjustments in temperature to ensure thorough baking while preventing excessive browning.Baking temperature for all control and experimental biscuits was 160^0C. Very slight variations were noted for mean weights of biscuits after baking with range of 10.63 - 11.92 g. Total biscuits weight before and after baking also showed difference, with makhana flour biscuits showed highest weight (168 and 155) and the maize flour biscuits the lowest weight (132 and 121). Thickness of all biscuits before and after baking also showed difference, in ragi flour showed minimum thickness (0.39 and 0.29 cm) and along with refined wheat flour biscuits jowar flour biscuits had maximum thickness (0.50 and 0.40). Very slight variations were noted for total number of biscuits (11 - 13).

SENSORY EVALUATION OF BISCUITS:

Table 5: Mean Palatability Scores for Control and Experimental Biscuits

Biscuits	Sensory Characteristics						
	Appearance	Colour	Texture	Doneness	Flavour	Taste	Acceptability
Control (Refined wheat flour)	10	10	10	10	10	10	10
Experimental-1 (Whole wheat flour)	10	10	10	10	10	10	10
Experimental-2 (Makhana flour)	10	10	10	10	10	9.88	10
Experimental-3 (Jowar flour)	10	10	10	10	10	10	10
Experimental-4 (Bajra flour)	10	10	10	10	10	10	10
Experimental-5 (Maize flour)	10	10	10	10	9.88	9.88	9.88
Experimental-6 (Ragi flour)	9.88	9.88	10	10	9.66	9.66	9.88
F Values	**0.5**	**0.5**	**0**	**0**	**0.6**	**0.6**	**0.5**

F values show insignificant differences.

Appearance and Colour:

From table 5, it is very clear that with the exception of experimental-6 biscuits (ragi flour), all other experimental biscuits received perfect 10 scores for their appearance. Ragi flour biscuits received slightly less mean score for its appearance& colour which was because of darkness of the flour.One-way ANOVA was applied between appearance as well as colour of control biscuits (refined wheat flour) and all experimental biscuits prepared using whole wheat flour, makhana flour, jowar flour, bajra flour, maize flour and ragi flour. The results showed insignificant differences at both 5% and 1% levels (F=0.5).

It was noted that chia seeds biscuits using makhana flour were slightly white in colour. Among all biscuits ragi flour biscuits were found to be darkest in colour and hence, received a mean score of 9.88 in comparison to control and other experimental biscuits. Bajra flour biscuits were found to be slightly greenish in colour and jowar flour biscuits light brownish in colour. All experimental biscuits received very good score for their appearance and colour (mean score 10).

These biscuits showcased diverse appearance owing to the incorporation of refined wheat flour, whole wheat flour, sorghum flour, pearl millet flour, makhana flour, and ragi flour.

Texture and Doneness:

Control and all experimental biscuits received perfect 10 scores for their texture and doneness. Biscuits showed crispy and flaky texture. Biscuits were properly baked with creamy mouthfeel. The comparisons showed insignificant differences at both 5% and 1% levels (F=0).

Biscuits crafted with a medley of chia seeds and an assortment of flours presented a delightful blend of texture and flavor.

Flavour and Taste:

Makhana, maize and ragi flour biscuits received insignificantly lower mean scores for taste than that of other biscuits (F=9.88, 9.88 and 9.66, respectively) which might be due to slightly bitter aftertaste. However, the differences were insignificant at both 5% and 1% levels (F=0.6). These biscuits were less sweet. Biscuits made using whole wheat flour, jowar flour and bajra flour received perfect scores of 10 for flavour and taste. Addition of chia seeds imparted slightly nutty flavour to biscuits.

Acceptability:

From table 5, it is observed that all experimental biscuits were very well accepted by the judges (F=0.5). Slightly lower acceptability of ragi and maize biscuits was due to appearance of these biscuits.

NUTRITIONAL QUALITY:

Table 6: Nutritive Value of Control and Experimental Biscuits

Nutrients	C	E1	E2	E3	E4	E5	E6
Energy (kcal)	451.43	444.24	450.34	447.40	450.56	447.40	444.35
Carbohydrate (g)	42.28	39.97	42.87	40.77	39.43	40.11	40.57
Protein (g)	12.58	12.63	12.43	12.49	12.72	12.23	11.85
Fat (g)	25.47	25.65	25.32	25.70	26.54	26.16	25.74
SFA (mg)	1190.02	1214.52	1167.55	1204.72	1367.06	1261.72	1239.83
PUFA (mg)	1705.96	1796.94	1627.75	1747.23	2080.13	1993.94	1726.03
MUFA (mg)	5285.66	5308.09	5274.12	5345.71	5512.85	5435.10	5407.51
α-Linolenic (n3) (mg)	18.50	24.76	14.52	18.29	46.44	23.81	30.16
Linoleic (n6) (mg)	1686.69	1771.51	1612.58	1728.41	2033.04	1969.42	1695.12
SDF (g)	0.58	0.82	0.44	0.84	0.97	0.67	0.82
IDF (g)	4.70	6.43	4.22	6.15	6.29	6.79	6.38
TDF (g)	5.29	7.25	4.67	6.99	7.28	7.45	7.21
Thiamine (mg)	0.27	0.33	0.24	0.31	0.29	0.31	0.32
Riboflavin (mg)	0.15	0.11	0.14	0.11	0.09	0.12	0.11
Niacin (mg)	2.66	3.02	2.49	2.97	2.69	3.10	2.79
Folate (µg)	17.58	10.93	17.58	8.60	9.36	11.70	9.68
Vitamin C (mg)	5.24	5.24	5.24	5.24	5.24	5.24	5.24
Carotene (µg)	27.45	26.84	27.45	29.34	33.89	69.86	27.80
Calcium (mg)	160.46	162.85	160.37	162.10	162.04	157.83	238.80
Phosphorus (mg)	281.53	328.28	276.97	318.93	322.35	320.07	304.33
Magnesium (mg)	119.37	140.87	112.37	142.70	140.65	145.43	145.66
Iron (mg)	3.32	3.86	3.25	3.83	4.39	3.49	3.98
Zinc (mg)	2.36	2.81	2.16	2.61	2.79	2.68	2.74
Sodium (mg)	152.01	152.13	151.67	157.66	152.60	152.68	152.75
Potassium (mg)	362.22	399.38	328.47	403.26	411.70	394.82	429.48

From table 6, it is clear that minute differences were noted between energy, carbohydrate, protein and fat content of biscuits. These biscuits were found to be energy dense with good fat content which was due to use of butter and chia seeds. Biscuits were found to be good in protein content also. These biscuits can be used in the diets of those people who are malnourished or underweight or population like school going children, adolescents, pregnant or lactating mothers or elderly since these biscuits are concentrated source of energy. MUFA content of biscuits was found to be very good (5274.12-5512.85 mg%). One can increase PUFA value of these biscuits (1627.75-2080.13 mg%) by using almond powder. The biscuits were found to be good in their n6 content. Use of chia seeds yielded higher SFA content (1167.55-1367.06 mg%) which cannot be used for therapeutic purpose.

Use of whole grain powders for making these chia seeds biscuits gave the products with very goof fibre content. Maize flour biscuits had highest IDF (6.79 g%) and TDF (7.45 g%) content. Biscuits prepared with whole wheat, jowar, bajra and ragi flours also had very good IDF and TDF values.

Not very high differences were noted between all experimental biscuits for thiamine, riboflavin and niacin content. Makhana flour biscuits had highest riboflavin & folate content 0.14 mg and 17.58 µg%, respectively) whereas maize flour had highest niacin (3.10 mg%) and carotene (69.86 µg%). Thiamine content if ragi flour biscuits was found to be highest (0.32 mg%).

Mineral profile of ragi biscuits was found to be very promising as it showed highest values per 100 g of biscuits for calcium (238.80 mg), magnesium (145.66 mg) and potassium (429.48 mg). Being a good source of iron, use of bajra flour in making chia seeds biscuits resulted in good amounts of iron (4.39 mg%). All biscuit varieties did not show major differences in sodium and zinc content.

COST:

Table 7: Cost of Control and Experimental Biscuits (Per 100g)

Sr. No.	Biscuits	Cost (Rs/-)
1	Control (Refined Wheat Flour)	38.22
2	Experimental-1 (Whole Wheat Flour)	38.24
3	Experimental-2 (Makhana Flour)	38.95
4	Experimental-3 (Jowar Flour)	38.42
5	Experimental-4 (Bajra Flour)	38.82
6	Experimental-5 (Maize Flour)	38.56
7	Experimental-6 (Ragi Flour)	38.59

It is observed that there is a very slight difference in the cost values of control and experimental biscuits (Rs. 38.22/- to 38.95/-).

CONCLUSION

Chia seeds, often hailed as a superfood, showed a profound impact on the appearance, color, texture, doneness, mouthfeel, flavor, and taste of biscuits prepared using different cereal & millet flours, elevating them to a whole new level of culinary excellence.

Chia seeds imparted a visually striking element to biscuits, as they were peppered throughout the dough, creating a beautiful mosaic of tiny specks. These seeds typically had a dark hue, ranging from black to brown, which contrasts against the lighter tones of the biscuit dough prepared with different cereal and millet flours.

The addition of chia seeds introduced a delightful textural dimension to the biscuits. As the biscuits baked, the seeds absorbed moisture from the dough, resulting in tiny pockets of soft gel-like texture within the crumb. This created a pleasing contrast to the crisp exterior of the biscuit, enhancing its overall mouthfeel.

The presence of chia seeds enhances the mouthfeel of biscuits by adding a subtle crunch and a unique chewiness. These tiny seeds provided a satisfying bite that complemented the tender crumb of the biscuit thereby creating a well-balanced texture that delighted the palate. Chia seeds contributed a mild, nutty flavor to biscuits. This subtle nuttiness added depth to the biscuit's flavor and hence, complemented the sweetness. In terms of taste, chia seeds imparted a delicate earthiness to biscuits, which harmonized beautifully with the buttery richness of the dough.

The appearance of these biscuits was both rustic and inviting. They boasted a golden-brown hue, with a slightly crumbly texture that promises a satisfying crunch with every bite. Speckles of chia seeds were generously scattered throughout, adding a visual and textural contrast against the backdrop of the various flours.The refined wheat flour contributed to the biscuit's lightness and delicate crumb, lending a subtle sweetness to its overall profile. In contrast, the whole wheat flour introduced a deeper, nuttier flavor and a slightly denser texture, providing a wholesome foundation to the biscuit. The sorghum flour imparted a mild, earthy aroma and a hint of sweetness, while the pearl millet flour added a subtle graininess and a touch of warmth to the flavor profile with greenish appearance. Furthermore, the makhana flour brought a unique element to the biscuits, offering a delicate crunch and a subtle nutty yet creamy flavor. Finally, the ragi flour, with its distinctive reddish dark hue, enriched the biscuits with a subtle earthiness and a boost of nutritional value. Collectively, these biscuits showed a harmonious balance of flavors and textures, ranging from light and crispy to hearty and wholesome. With their rich color palette and diverse ingredients, these chia seed biscuits were as visually appealing as they were nutritionally delicious, making them a delightful treat for any occasion.

In conclusion, chia seeds showed a multifaceted impact on the characteristics of biscuits, from their appearance and texture to their flavor and taste. Their inclusion added a touch of nutritional value to the biscuits. Chia seeds biscuits are good source of energy and other nutrients. Chia seeds biscuits can be successfully designed using different cereal and millet flours along with nuts and sugar without affecting sensory quality. These chia seeds biscuits showed good micronutrient profile. These prepared biscuits can be given to pregnant women, lactating women, malnourished children and adults, school going children, adolescents, elderly etc.

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