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Formulation and quality evaluation of cookies fortified with flaxseed flour

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ABSTRACT

The bakery industry offers a wide variety of products which includes bread, biscuits, cookies, cakes, pastries, and muffins. Wheat is considered to be one of the most important ingredients in bakery products. Fortification of cookies by replacing wheat with nutritional-rich alternatives is essential to increase the nutritional value of cookies. In this study, cookies were fortified with flaxseed flour, foxtail millets and ragi flour to enhance their nutritional profile, thus overcoming the limitations associated with using wheat flour. The outcome and effects of fortification with varying levels of flaxseed flour were analyzed. The different formulations were as follows – T_0 (100:0, wheat: flaxseed), T_1 (80:10:10, foxtail + ragi flour: flaxseed flour: wheat flour), T_2 (70:20:10), and T_3 (60:30:10). The organoleptic properties of samples were assessed using a 9-point Hedonic scale by a group of 8 semi-trained panelists. The sample T_2 containing 20% flaxseed was the most preferred and accepted by the panelists in terms of appearance, taste, texture and overall acceptability. The analytical tests were conducted for the moisture content, fat percentage, protein content, ash content and titratable acidity of cookies. Results indicated that - as the concentration of flaxseed flour increased, the moisture content, ash content, fat percentage and protein percentage in cookies also increased. The inclusion of ragi flour also increases the calcium content of cookies as ragi is the richest source of calcium of all flours. Therefore, fortification of cookies with flaxseed flour, foxtail millets and ragi flour remarkably enhanced both their nutritional composition and sensory attributes.

Keywords: Fortified cookies, Flaxseed flour, Flaxseed cookies, Foxtail millets, Ragi flour

Introduction

The global inclination towards healthy and nutritious food have notably escalated the interest of health-conscious consumers towards food and food products that provide potential health advantages; focusing towards functional foods. Cookies are popular bakery products that are chemically leavened product. It is also considered as “biscuit” in some countries. Cookies are a perfect vehicle for providing nutrients and health benefits to consumers (Elshehy *et al.*, 2018) [1]. Generally, the principle ingredients are wheat flour, sugar, fat and water/milk. Refined wheat flour used in standard cookies is low in fiber, proteins (7-14%), essential amino acids, imbalanced fatty acid profile, high saturated fat and high carbohydrate content. These traditional cookies and biscuits are not considered nutritious. Therefore, due to these limitations, there is a remarkable increase in the development of healthy, natural and functional cookies. This specifically requires products that are sugar-free, high-fiber and low-calorie. (Khouriye *et al.*, 2012) [2]

Flaxseed or linseed (*Linum usitatissimum*) has gained popularity due to its nutritional profile and health benefits. It is blue-colored flowering crop grown in rabi season. The seeds of flax are small, flat, smooth and pointed at ends. It is also known by other names such as Alsí, Jawas and Aksebija in Indian languages. It has been used as a medicine since ancient times. It is gluten-free and has an amino acid profile similar to that of soybean flour (Ganorkar *et al.*, 2014) [3].

Flaxseed has nutritional composition – 30% protein, 35% fiber and 35% lipids. This composition differs depending upon seed variety, cropping year, location of cropping and environmental conditions. The protein content ranges from 10.5% to 31% in flaxseed, varies depending on environment and conditions of growth. Significantly, its key components comprise of dietary fibers, oils (lipids), phenolic compounds (lignans), and proteins. Fatty acid profile of flaxseed is unique (Alka *et al.*, 2017) [4]. It contains high concentration of PUFAs (polyunsaturated fatty acids) and low content of saturated fatty acids. Flaxseed oil and its derivatives contain –

Polyunsaturated fatty acids: Total PUFA content of flaxseed is reported to be 60.3% (yet another study reported it to be 70%). Alpha linolenic acid (Omega - 3 fatty acid) is found to be abundantly present in flaxseeds, accounting to about 47.2% - 53%.

Flaxseed is also rich in calcium, which is important for mineralizing bone matrix. Flaxseed along with ragi flour significantly increases the calcium content of the cookies. Due to these components present in flaxseed,

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it provides numerous health benefits. Flaxseed is known to reduce the risk of cardiovascular diseases, hyperlipidemia, cancer and diabetes. It also reduces bad cholesterol "LDL" levels. In accordance to these nutritional advantages provided by flaxseed, it is incorporated into cookies and other bakery products. As cookies are ready-to-eat, highly convenient and affordable bakery products, they are suitable to be incorporated with flaxseed to enhance their nutritional value (Ganorkar *et al.*, 2014) [3].

Flaxseed flour is blended in different proportions with foxtail millet flour and ragi flour. These flours have a synergistic effect on the nutritional value of cookies. Dates consist of 6.4-11.5% fibre; both soluble and insoluble. It has low glycemic index (GI) and hence is *anti-diabetic* and helps improve lipid and glucose profiles. (Jain, 2013) [5]. Foxtail Millet and ragi flour are low glycemic index (GI) flours, aiding in diabetes and weight-management (SIRISHA, 2016) [6]. Foxtail millet flour increases the protein content and dietary fiber content of cookies (Sachdev *et al.*, 2021) [7]. Other ingredients added are sugar, butter, baking powder, dates, salt and choco chips.

2. Material and Methods

This experimental study on "Formulation and Quality Evaluation of cookies enriched with flaxseed flour" was conducted in the Food technology lab in ITM University, Gwalior, Madhya Pradesh, India.

Materials

2.1 Collection of material

All the ingredients – Flaxseed, ragi flour, foxtail millets, sugar, dates, baking powder, butter, and choco chips were collected from the local market in Gwalior.

Preparation of flaxseed flour

Flaxseed collected from market

Roasting at 180 °C for 2 minutes in a saucepan

Cool for 2-3 minutes

Grinded in a mixer grinder

Sieving

Flaxseed flour collected

Preparation of foxtail millets flour

Foxtail Millets collected from market

Roasting at 180 °C for 2 minutes in a saucepan

Cool for 2-3 minutes

Grinded in a mixer grinder

Sieving

Foxtail Millets flour collected

Figure 1. Preparation of Flaxseed flour

Figure 2. Preparation of Foxtail millets flour

2.2 Treatments

T₀ = Control Cookies prepared with 100% wheat flour. Wheat Flour was substituted with mixture of Foxtail millets flour + Ragi flour

T₁ = Foxtail + Ragi flour: Flaxseed flour = 90:10

T₂ = Foxtail + Ragi flour: Flaxseed flour = 80:20

T₃ = Foxtail + Ragi flour: Flaxseed flour = 70:30

2.3 Formulation concept

The composition of various ingredients of T₀ (control cookies) and T₁ (experimental cookies) is as follows:

Procedure for preparation of cookies

Procurement of all the ingredients

Flaxseed flour, Foxtail + Ragi (F+R) flour and Wheat flour taken in different proportions

Control (100g) Fortified Experimental Flour (100g)

Table 1. Raw material composition

INGREDIENTS	T ₀ (CONTROL)*	T ₁	T ₂	T ₃
Wheat flour	65g	10g	10g	10g
Flaxseed flour	-	5g	10g	15g
Foxtail millet flour	-	25g	25g	25g
Ragi flour	-	25g	20g	15g
Sugar	15g	15g	15g	15g
Butter	15g	15g	15g	15g
Baking powder	2g	2g	2g	2g
Dates	-	3g	3g	3g
Salt	Pinch (~1g)	Pinch (~1g)	Pinch (~1g)	Pinch (~1g)

* The values for standard cookies formulation were taken from reference of other literature works.

Wheat flour 100% (T₀)

(Standard cookies) T₁ (80:10:10) T₂ (70:20:10) T₃ (60:30:10)

(F+R: Flaxseed: Wheat flour)

Mix all the dry ingredients (Flours, baking powder, salt). Take butter and powdered sugar in 1:1 ratio. Beat with a whisker to make cream

Add dry ingredients to the cream. Grind some dates to make a paste and add it to the mixture. By slowly adding water/milk, knead the

mixture to make dough.

Shape the cookies and pour choco chips on the top surface for good appearance.

Preheat the oven at 180 °C for 5 minutes. Bake the cookies at 180 °C for 20-25 minutes and Cool.

Figure 3. Procedure for preparation of cookies

Figure 6. Flaxseed cookies ready



Figure 5. Baking of flaxseed cookies in microwave oven at 180 °C



Figure 6. Flaxseed cookies ready

Methods

2.4 Proximate analysis

2.4.1 Moisture content [AOAC 925.10]

Moisture content is the amount of free water present in the food sample. It influences the shelf-life and stability of food products. It promotes the growth of micro-organisms and spoilage of cookies. The sample is heated at a certain time-temperature combination to remove all the water present in the food sample.



Figure 4. Dough for flaxseed cookies

Principle: Removal of free water by heating the food sample at 105°C for 3 hours. This completely dries the material, reducing the moisture content of food. This loss of weight of water is measured in comparison to the weight of sample to calculate the moisture content.

Procedure: Weigh 5g of sample in a Petri dish. Place it in a hot air oven at 105°C for 3 hours. After drying, place the heated sample in a desiccator to cool. Re-weigh the sample and note the readings

Calculation: Initial Weight (W_1) = Weight of empty Petri dish + Weight of sample

Final Weight (W_2) = Weight of Petri dish + sample after drying

Weight of sample (W) = Weight of sample taken

Formula:

$$\% \text{ Moisture} = \frac{W_1 - W_2}{W} \times 100$$

W

2.4.2 Ash content [AOAC 942.05]

Ash content is a method of evaluating the amount of inorganic matter and minerals present in a food sample that are not destroyed during heating.

Principle: Organic matter is incinerated at high temperature (550°C) for 4 hours, which leaves the inorganic matter and residues.

Procedure: Weigh 5g of sample in a crucible. Place it in a muffle furnace at 550°C for 4 hours. After ashing, place the heated sample in a desiccator to cool. Re-weigh the sample and note the readings

Calculation: Initial Weight (W_1) = Weight of empty crucible

Final Weight (W_2) = Weight of crucible + sample after ashing

Weight of sample (W) = Weight of sample taken

Formula:

$$\% \text{ Ash} = \frac{W_2 - W_1}{W} \times 100$$

W

2.4.3 Fat percentage by Soxhlet apparatus [AOAC 2003.05]

It is a method of estimating crude fat content using repeated extraction of fat with the help of a non-polar, organic solvent. The sample must be dried and ground before extraction for efficient and successful extraction of fat.

Principle: The sample is dried and ground. It is then placed in a thimble and put into the Soxhlet apparatus. The solvent is filled in a round bottom flask and heated to vaporize. The vaporized solvent rises and condenses through the condenser and falls onto the thimble, dissolving the fat. The solvent again falls into the round bottom flask. This cycle repeats until all the fat is dissolved and extracted from the sample. After extraction, the solvent containing fat is heated to evaporate the solvent. The solvent evaporates, leaving behind fat.

Procedure: Take 2g sample in the thimble and place it on the apparatus. Weigh the conical flask and add solvent (petroleum ether). Heat the flask. After extraction is completed, heat the conical flask to evaporate the solvent. Weigh.

Calculation: Initial Weight (W_1) = Weight of empty flask

Final Weight (W_2) = Weight of flask + sample after extraction

Weight of sample (W) = Weight of sample taken

Formula:

$$\% \text{ Fat} = \frac{W_2 - W_1}{W} \times 100$$

W

2.3.4 Titratable acidity [AOAC 940.28]

Organic acids are responsible for the acidity in food products. The amount of acid present in the food directly influences its spoilage. Titratable acidity is the amount of acids present in any food sample.

Principle: Total acid content is evaluated by titration method. An aliquot of sample is titrated against a base of known strength with the help of an indicator, generally phenolphthalein indicator, which indi

cates the end point of titration with color change from colorless to light pink.

Procedure: Take 5g grinded sample and transfer into conical flask. Add 10 mL distilled water to the conical flask and blend. Add 2-3 drops of phenolphthalein indicator. Fill the burette with 0.1N NaOH. Titrate until the solution turns light pink color and note the reading.

Calculation: mL = volume of NaOH used (titrate value)

N = Normality of NaOH

90 = Equivalent weight of lactic acid

V = Volume of sample used

Formula:

$$\% \text{ Acidity} = \frac{\text{mL} \times \text{N} \times 90 \times 100}{\text{V} \times 1000}$$

2.5 Sensory evaluation study

Sensory evaluation is a scientific discipline used to measure the qualities or characteristics of a food product using 5 senses taste, touch, hearing, sight and smell (Kemp, 2008) [8].

It can be done by many methods such as descriptive, discriminative and effective tests. Consumer acceptance is determined of the fortified cookies using sensory evaluation. By using a 9-point hedonic scale, color, aroma, taste, texture and over all acceptability is evaluated. Panelists are trained and evaluation scorecards are distributed to efficiently conduct the sensory evaluation (Amerine *et al.*, 2013) [9].

Table 2. Table showing results of proximate analysis

PARAMETERS	T0 (CONTROL)	T1	T2	T3
Moisture content	4.78%	6.85%	8.40%	10.37%
Ash content	0.18%	0.67%	1.42%	1.98%
Fat (%)	17.35%	25.32%	28.51%	36.37%
Titrateable acidity	0.32%	0.42%	0.44%	0.51%

3.2.2 Ash content

The ash content of T_2 was found to be 1.42% by muffle furnace method as compared to the 0.18% in T_0 (control) cookies and significantly increased with each formulation. The ash content significantly increased due to high amount of minerals present in flaxseed, foxtail millets and ragi flour.

3.2.3 Fat estimation by Soxhlet method

The crude fat content of T_2 was found to be 28.51% by Soxhlet extraction method as compared to the 17.35% in T_0 (control) cookies. The crude fat content significantly increased due to the fatty acid profile of flaxseed, foxtail millets and ragi flour.

3.2.4 Titrateable acidity

The titrateable acidity of T_2 was found to be 0.44% by titration method which implies the presence of organic acids in flaxseed, foxtail millets and ragi flour.

3.3 Sensory evaluation

The results from the sensory evaluation study revealed that T_2 formulation was acceptable in terms of appearance, taste, texture and over-all acceptability. The result for sensory evaluation study includes the average scores of all attributes.

4. Conclusion

Cookies are chemically leavened snacks that are one of the most widely consumed bakery products because of the long shelf-life, taste affordability and convenience. They were traditionally been consid-

3. Results and discussion

3.1 Proximate analysis results

The cookies were evaluated for their quality and sensory attributes. The results from the tests are given in the following table -

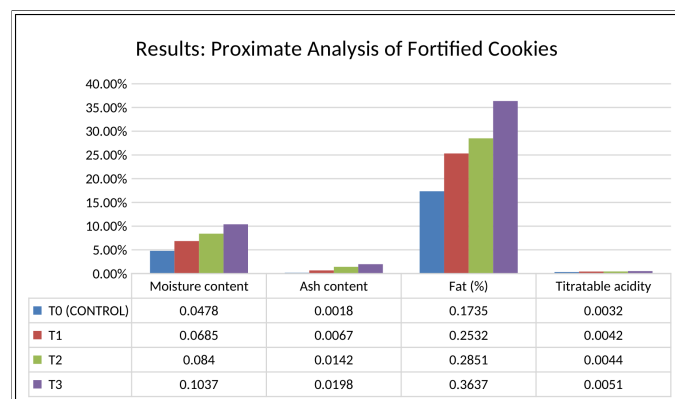


Figure 7. Graph showing results of proximate analysis

3.2 Discussion

3.2.1 Moisture content

The moisture content of T_2 was found to be 8.40% by hot air oven method. By comparing the results of T_0 (control) cookies, the moisture content significantly increased in each formulation due to fortification of flaxseed, foxtail millets and ragi flour.

ered as energy-dense snacks which were made from refined wheat flour, fat and sugar.

In recent years, the cookies are being considered a suitable vehicle for providing nutrients, hence they are enriched and fortified with many functional ingredients that provide macronutrients and micronutrients. These cookies have enhanced nutritional value, palatability, affordability convenience, and high consumer acceptance. They study was undertaken to develop functional cookies by incorporating nutrient rich ingredients such as millets, flaxseeds and Ragi flour, which improve the nutritional value and health benefits of the cookies. The developed cookies were high in dietary fiber, good unsaturated fats such as Omega-3 fatty acid, routines antioxidants and essential minerals such as calcium. Total PUFA content of flaxseed is reported to be 60.3% (yet another study reported it to be 70%). Alpha linolenic acid (Omega-3 fatty acid) is found to be abundantly present in flaxseeds, accounting to about 47.2 % - 53%. Ragi flour and flaxseed had a synergistically increased concentration of calcium in the cookies.

The cookies were tested for the proximate composition and sensory evaluation. The proximate analysis showed a gradual increase in moisture, ash, and fat due to the substitution of flaxseed, foxtail millets and Ragi flour. The fortified cookies enriched with flaxseed flower significantly enhanced the nutritional qualities of cookies. Moisture content increased to a double rate compared to the standard cookies made with refined with. There was a similar increase in the Ash content due to the addition of flaxseed, foxtail millets and Ragi flour, enhancing the mineral content. The fatty acid profile of flaxseed enriched the cookies with higher fat percentage and high-quality fatty acids compared to the standard cookies. The flaxseed enriched cookies also contain appreciable amounts of Omega-3 fatty acids. The pro

tein content was significantly low due to high amount of carbohydrates and less amount of protein in the flours. The title table acidity was found to be 0.44% which indicates good freshness and low microbial load.

Sensory evaluation studies revealed that the enriched cookies with 10% flaxseed flour were highly acceptable in the sensory attributes like taste, appearance, texture and overall acceptability. The further research can be recommended to evaluate the storage stability, glycemic index, fatty acid profile and commercialization of the cookies. Additionally, consumer behavior with wider population can also provide deep insights into market acceptance.

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