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Development and Physio-Chemical Analysis of Amaranth and Foxnut Flour-Based Nutrient-Rich Cookies

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Abstract: *The development and physio-chemical analysis of Amaranth and Foxnut flour-based nutrient-rich cookies were studied at the Department of Food Technology, Parul Institute of Applied Sciences, Parul University, Vadodara. The main goal of developing nutrient-rich cookies is to provide macronutrients as well as micronutrients such as Protein, Fat, Carbohydrates, Dietary fiber; and Iron, Zinc, and Potassium respectively. The nutrient-rich cookies are beneficial for gastrointestinal cancer, lowering the level of LDL (Low-Density Lipoprotein), and guarding against anemia, constipation, and kidney issues. Four different formulations were prepared T0, T1, T2, and T3 by using amaranth flour, foxnut flour, and wheat flour in the different ratios of 0:0:1, 1:1:2, 1:2:4, and 1:1:3 respectively. The best composition (T2) is used for sensory evaluations like color, texture, flavor, and overall acceptability. These cookies were evaluated for physical (thickness, diameter, spread ratio, and bake loss), textural, and organoleptic attributes. The diameter and spread ratio were found to be higher in whole amaranth flour and foxnut flour cookies 48mm and 11.70 respectively. Textural measurement showed that the hardness of cookies decreased with the addition of amaranth and foxnut flour. The final composition contained 318.93kcal Calories, 8.36% Total Protein, 61.9% Total Carbohydrate, 25.38% Total Fat, 4.21% Dietary Fiber, 2.35% Moisture, 2.01% Total Ash, 25.68mg/kg Zinc, 140.81mg/kg Iron, and 1655.35mg/kg Potassium. For folks who eat them regularly, cookies' high nutritional value works as an immunity booster.*

Keywords: Amaranth flour, Foxnut flour, Wheat flour, Nutrient-rich Cookies

I. INTRODUCTION

Cookies provide a beneficial dietary supplement and vehicle for nutritional enhancement because they are generally accepted and consumed in many nations. Given that they are ready to eat, a good source of energy, and are popular worldwide, cookies have been recommended as a good way to utilize composite flours. Cookies, or biscuits as they are known around the world, are baked goods that typically have three main ingredients flour, sugar, and fat. To create the dough, these are combined with a few more minor components. (Francine Zucco, Yulia Borsuk, Susan D. Arntfield.2011) Due to their widespread acceptance, practicality, and shelf-life, cookies are among the most popular snack foods. The use of flour and components from diverse sources in cookie goods has become more popular over time. (D.J. CHEN. K. WEINGARTNER and M.S. BREWER. 2003.)Cookies are good replacers in daily meal diet, they can be eaten like RTE (Ready-To-Eat) food products.

Amaranthus plants (Amaranthaceae) can be grown in a wide range of climatic circumstances to provide beneficial feed and food items or to infest other plants. (Rastrelli, L.,1995). Pseudocereals are generally considered whole grains, high in protein and other nutrients, and gluten-free. The "Amaranth family" is commonly referred to as the family Amaranthaceae. The Greek word "Anthos" (Flower) is the main source of the English term "amaranthus," which basically means "everlasting." (Sharma, A., 2017).When compared to other cereals, amaranth seeds have a relatively low content of saponins (0.09 percent), which results in low toxicity. Only a minimal number of saponins are absorbed, and they are harmful to the digestive tract. These substances can combine with zinc and iron to create complexes, which reduces their bioavailability. Saponins have anti-inflammatory, anti-microbial, cholesterol-lowering, immune-

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modulating, and anti-carcinogenic properties. Therefore, there is no risk to the user from items made from amaranth. (Sharma, A., 2017).

In Hindi and Punjabi, Euryale Ferox is frequently referred to as Makhana, foxnut, or Gorgon nut. It is a blooming plant that belongs to the Nymphaeaceae family of water lilies, although occasionally being mistakenly identified as a member of the separate Euryalaceae family. It is grown in several regions of China. In the calm, freshwater pools of the northern and northeastern states of India, gorgon nut, an aquatic vegetation, flourishes. The seed is eaten in the popped form in North Bihar, but the leaves and stalks are eaten as vegetables in Manipur. The gorgon nut has strong antioxidant activity that has been linked to medical uses including the prevention of proteinuria or diabetic nephropathy. In India, gorgon nuts, also known as Euryale Ferox, are eaten as a delicious and nutrient-dense food. The plant yields edible starchy white seeds.Due to its low-fat content and great nutritional value, it is one of the most often consumed dry fruits and a storehouse of macro and micronutrients. Various research established the physical and hygroscopic qualities of Makhana that are suitable for use in preparing meals for newborns as well as all aged people. (Malvika Bana, Rajinder K Gupta.2015.)

In order to gauge consumer sensory reactions to these products, this study set out to determine consumer preferences for cookies produced with foxnuts, amaranth, wheat flour, and other ingredients. Cookies made from composite flour including different amounts of whole amaranth and foxnut were produced in light of the nutritional advantages of these two grains. The aim of this study was to characterize the physicochemical and sensory properties of these two flourless biscuits. Cookies are advantageous for both deficits because they are rich in minerals protein and iron. Similar to how a protein deficiency can result in decreased immunity, mental sickness, muscle atrophy, and bone fractures. According to estimates, 30% of the world's population suffers from iron insufficiency, making it by far the most common nutritional shortage globally. Reduced levels of myoglobin, iron-containing enzymes, and circulating hemoglobin all contribute to the functional repercussions of iron deficiency Anemia. The main effects include diminished immunological function, fatigue, and subpar work performance in addition to lower psychomotor and cerebral development in newborns.

II. MATERIALS AND METHODOLOGY

2.1. Material

Amaranth grains and foxnuts were purchased from a local market in (Vadodara, Gujarat) India. Grains were cleanedand stored in an airtight container in refrigeration conditions at 4°C till further used. Wheat flour, butter, sugar, baking soda, baking powder, and choco chips were purchased from a local market in (Vadodara, Gujarat) India.

2.2. Equipment used

- Weighing balance: Electronic weighing balance is used for weighing raw materials.
- Electronic blending machine (planetary mixer): It is used for mixing and blending ingredients like fat and sugar.
- Dough roller: It is used for making dough sheets and obtaining uniform thickness.
- Oven: Baking of cookies is done at 180□c for 12-15 minutes

2.3. Methods

2.3.1. Preparation of Amaranth Flour

Amaranth grains were washed with water 2–3 times and then dried in a hot air oven for 2 h. After drying, the grains were milled in the grinder. To get uniform particle size, the flour was passed through a 60-mesh sieve and stored at room temperature conditions till further analysis.

2.3.2. Preparation of Foxnut Flour

Dried foxnuts wereroasted and nuts were evenly distributed in a single layer over an aluminum plate in preheated (130 ± 2 °C) hot air oven for 10 min. It was further cooled and milled in a grinder. To get uniform particle size, the flour was passed through a 60-mesh sieve and stored at room temperature conditions till further analysis.

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2.3.3. Proximate Composition

The chemical composition of the flours, (amaranth, foxnut, and wheat) including the moisture, fat, ash, fiber, and protein content, were determined by the AOAC methods (AOAC, 1995).

2.4. Cookies Formulation

Cookies were made from wheat to serve as a control. The amaranth flour and foxnut flour were mixed with wheat flour at different levels (0:0:1; 1:1:2; 1:2:4; 1:1:3) to prepare cookies. The cookies were prepared using the following ingredients: Amaranth flour (30gm), foxnut flour (15gm), wheat flour(60gm), shortening (butter)(25gm), sugar (25gm), baking soda (2gm), baking powder (2gm) and, Choco-chips (15gm). Shortening and sugar were mixed to form a cream, then added to the mixture of flour, baking soda, and baking powder, choco-chips, and mixed thoroughly to form a dough. The dough was kneaded and sheeted to a uniform thickness of 0.25 cm and cut into circular shapes of 5 cm in diameter. Baking was carried out at 180°C for 12-15 min. Cookie samples were cooled and stored in airtight containers.

Table 1: Ingredients and quantity used in the production of nutrient-rich cookies

Ingredients	T0 (0:0:1)	T1(1:1:2)	T2 (1:2:4)	T3(1:1:3)
Amaranth Flour	-	25 gm	30gm	20 gm
Foxnut Flour	-	25 gm	15gm	20 gm
Wheat Flour	25 gm	50 gm	60gm	60 gm
Butter	13 gm	100 gm	75gm	70 gm
Sugar	13 gm	38 gm	75gm	50 gm
Baking soda	1 gm	1 gm	2gm	1 gm
Baking powder	1 gm	1 gm	2gm	1 gm
Choco-chips	-	10 gm	15gm	10 gm

2.5. Physical Analysis

Diameter and thickness were measured with a vernier calliper at two different places in each cookie and the average was calculated for each (one value was considered for each cookie). The spread ratio was calculated using the formula: diameter of cookies divided by the height of cookies. Five cookies were weighed both before and after baking to determine the 'bake loss.' The weight difference was averaged and expressed as a percentage of bake loss. (Arti Chauhan, D.C. Saxena and Sukhcharn Singh.2016).

2.5.1. Color analysis

Color measurement of cookies was carried out using a Hunter Colorimeter fitted with an optical sensor (Hunter Associates Laboratory Inc., Reston, VA, USA) on the basis of the CIE L*, a*, b* color system. L* values measure black to white (0–100), a* values measure redness when positive, and b* values measure yellowness when positive. (Arti Chauhan, D.C. Saxena and Sukhcharn Singh.2016).

2.5.2. Texture Analysis

The hardness of the baked cookies was measured using a texture analyzer (TA-XT2i, Stable Micro Systems, UK) in a compression mode with a sharp blade-cutting probe. Pre-test, test, and post-test speeds were 1.5, 2, and 10 mm/s, respectively. Hardness, a maximum peak force, was measured with more than six cookies for each sample. The peak force to snap the cookies was reported as fracture force in N. (Arti Chauhan, D.C. Saxena and Sukhcharn Singh.2016).

2.6. Chemical Analysis

The determination of chemical composition of the cookie samples viz: moisture content, ash, protein, fat, fiber, carbohydrate, and Energy contents were determined by methods described by AOAC (1990).

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2.7. Microbiological Analysis

The determination of the microbial quality (mold and yeast counts) of the products was performed by the method outlined in a compendium of methods for the microbiological examination of foods (AMPH, 1992) with some modifications.

2.8. Sensory Evaluation

Cookies made from wheat, whole amaranth seed flour, and foxnut flour were subjected to sensory evaluation as shown in Table No.6, using semi-trained panelists drawn within the University community. The cookies were evaluated forcolor, texture, flavor, and overall acceptability. The ratings were on a 9-point hedonic scale ranging from 9 (like extremely) to 1 (dislike extremely). All panelists were regular consumers of cookies. Water at room temperature was provided to rinse the mouth between evaluations. The control was cookies made from 100% wheat flour.

III. RESULTS AND DISCUSSION

3.1. Proximate Composition of Amaranth, Foxnut, and Wheat Flour

The chemical compositions of wheat, amaranth flour, and foxnut flour used for cookie preparation are shown in Table 1. Amaranth flour and foxnut flour was found to have high crude protein, crude fat, crude fiber, and ash content.

Table 2: Proximate Composition of Wheat, Amaranth Flour, and Foxnut flour

	Wheat Flour	Foxnut Flour	Amaranth Flour
Moisture	7.20±1.31	11.2 ± 0.163	8.13 ± 0.15
Protein	12.85±2.25	11.16±1.25	15.05 ± 0.05
Fat	3.55±1.25	0.51±0.60	3.0 ± 0.03
Fiber	4.67±1.38	0.80 ± 0.88	13.40 ± 0.41
Ash Content	1.70 ±0.80	0.4±0.80	2.93 ± 0.08

Source: *(Joel Ndife, Fatima Kida, and Stephen Fagbemi,2014; Arti Chauhan, D.C. Saxena1 and Sukhcharn Singh.2016; Pritha Biswas, and others.2020.)*

3.2. Physical Properties

Table no. 3 physical characteristics (thickness, diameter, spread ratio, and bake loss) for the six different types of cookies demonstrate how the amount of amaranth and foxnut flour raised the height of the cookie samples T0, T1, T2, and T3. As a result, each sample's thickness, diameter, spread ratio, and bake loss were significantly different from one another. The diameter-to-height ratio is known as the cookie spread ratio. The best cookies are those that have a higher spread ratio. The spread ratio of the composite cookies demonstrated a growing trend, according to the results, coupled with an increase in the amount of foxnut and amaranth flour substituted. As the ratio of foxnut flour and amaranth flour in the mixture rose, the bake loss of cookies was reduced. Due to their high protein content, foxnut and amaranth flours may store more water than wheat flour, which is the cause of this. A measure of cookie quality is the spread ratio and bake loss. (Arti Chauhan, D.C. Saxena1 and Sukhcharn Singh.2016.)

Table 3: Physical analysis of nutrient-rich cookies

Samples	Weight (g)	Height (mm)	Diameter (mm)	Spread ratio	Bake loss (g)
T0(Control)	6	4.4	46	10.45	15
T1	6.2	4	46	11.5	14.28
T2	7.6	4.1	48	11.70	11.62
T3	6.6	4.2	47	11.19	13.95

3.3. Color analysis

The color measurements of the composite cookies were substituted with different levels of amaranth flour and foxnut flour. From the results, it was noticed that the lightness (L*) of the composite cookies displayed a decreasing trend along with the increasing substitution level of amaranth flour. The reducing values of L* indicate that the composite cookies are darker in color at higher levels of substitution. On the other hand, a reverse trend was noticed for redness (a*) and yellowness (b*) in composite cookies. The increase in a* and b* values were noticed as the amaranth flour and

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foxnut flour level increased in cookie preparation. Protein content was negatively correlated with the lightness of the cookie, indicating that the Maillard reaction played a major role in color formation. Maillard browning and caramelization of sugar are considered to produce brown pigments during baking. The cookie color is an important factor in the initial acceptability of food products by consumers. (Arti Chauhan, D.C. Saxena1 and Sukhcharn Singh.2016.)

3.4. Texture Analysis

The texture result of the six types of cookies prepared from a blend of wheat, whole amaranth flour, and, foxnut flour. Hardness differs significantly in all cookie samples. The decrease in hardness with amaranth flour and foxnut flour substitution in cookies could be attributed to the changes in gluten content. The changes in total protein content were not as significant as the change in gluten content for the formation of a composite matrix of cookie dough. Gluten is primarily responsible for creating the continuous protein matrix in short-dough cookies like sugar-snap cookies during baking. Therefore, the amaranth flour and foxnut flour substitutions that reduced the amount of gluten in the cookie dough delayed the development of gluten matrices, which contributed to the significant reduction in hardness. They showed that the force required to break the cookies significantly decreased with the addition of amaranth flour and foxnut flour cookies. (Arti Chauhan, D.C. Saxena1 and Sukhcharn Singh.2016.)

3.5. Chemical Composition

Table 4 shows the results of the chemical composition of the nutrient-rich cookies. Cookies with increased amaranth flour and foxnut flour substitutions were found to be nutritionally superior (have higher proximate values for protein, fat, dietary fiber, carbohydrate content, and mineral contents) to whole-wheat cookies. The moisture contents of the cookies decreased with amaranth and foxnut flour substitution by a range of 9.85% to 2.35%.High moisture content has been associated with the short shelf life of baked products, as they encourage microbial proliferation that leads to spoilage. (Joel Ndife, Fatima Kida and Stephen Fagbemi.2014.)

The ash content also decreased from 2.15% to 2.01% in the cookies produced from amaranth and foxnut flour substitution. Ash is an indication of the mineral contents of food. (Alabi and Anuonye. 2007). The dietary fiber content of the cookies showed a percentage increase in the range of 3.29% to 25.38% as whole wheat flour was substituted with amaranth and foxnut flour.

Protein is rich in the Control sample (T0) which is made up of using whole wheat grain flour. The supplements flour (amaranth and foxnut) with wheat flour they are also maintains the protein percentage in the cookie. If the amount of amaranth and foxnut flour increases in cookie composition, then the percentage of protein also increases. In amaranth and foxnut cookies high protein content in (T2) and the lowest protein content in (T1).

The fat content also increased from 4.50% to 25.38% in the cookie samples. Sample T2 had the highest percentage of fat content compared to sample T0 (whole wheat cookies). The high oil content and butter of the cookies will affect the shelf stability. (Potter and Hotchkiss, 2006). Fat is an essential component of tissues and a veritable source of fat-soluble vitamins (A, D, E, and K). It is able to supply thrice the amount of energy required by the body. (Wardlaw, 2004).

The increased fiber and the lower carbohydrate content of cookies have several health benefits, as they will aid digestion in the colon and reduce constipation often associated with products from wheat grain flour. (Slavin, 2005; Elleuch et al., 2011). whole wheat flour in combination with amaranth and foxnut flour in biscuit production resulted in improved nutritional and functional properties of the final products.

Iron is the most abundant element in all the cookie samples. The highest potassium content (14.081mg/kg) was recorded in the sample (T2) in amaranth and foxnut flour blended. The mineral content of the cookie samples increased with amaranth and foxnut flour substitution for all the minerals analyzed, except for zinc and potassium. Sample T0 (whole wheat flour) had the highest content of zinc and potassium (4.38mg/100g and 165.535mg/gm) respectively.

Table 4: Chemical Composition of Nutrient-rich Cookies

Parameters	T0	T1	T2	T3
Moisture (%)	9.85±1.52	5.34±1.55	2.35±1.60	7.56±1.58
Ash Content (%)	2.15±0.85	2.10±0.90	2.01±0.65	2.06±0.70

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Protein (%)	8.75±2.23	6.67±2.00	8.36±2.15	7.89±2.24
Fat (%)	4.50±0.30	23.30±0.32	25.38±0.30	23.56±0.34
Dietary Fiber (%)	3.29±1.35	3.78±1.39	4.21±1.45	4.11±1.42
Carbohydrates (%)	70.45±3.15	63.52±3.20	61.9±3.55	68.24±3.32
Iron (Fe), mg/kg	2.10±0.13	8.69±0.11	14.081±0.12	11.3±0.11
Zinc (Zn), mg/kg	4.38±0.10	1.96±0.11	2.568±0.10	2.87±0.12
Potassium(K), mg/kg	412.47±1.92	161.23±1.63	165.535±2.30	163.10±2.14

3.6. Microbial Properties

The results obtained from the microbial quality investigated are shown in Table 5. The results obtained for total plate counts were negligible (not present) in all the cookie samples (<1.5×10² cfu/g). The butter and fiber contents are critical to the survival of microbes and will ultimately affect the shelf stability and sensory quality of the cookie samples (Ezeama, 2007). There were no observable yeast and mold growths from all the cookie samples. This eliminates the possibility of fecal contamination in the different cookie samples, which is a pointer to good production and handling practice. This could also be due to the dry nature of the cookie samples (Ezeama, 2007).

Table 5: Result of microbiological analysis of the nutrient-rich cookies(Cookies samples cfu/g)

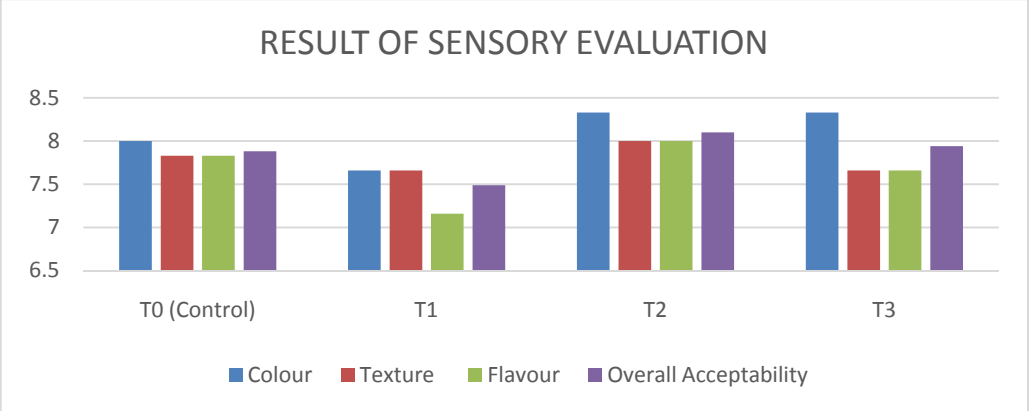
Parameters	**T0**	**T1**	**T2**	**T3**
TPC	NG	NG	NG	NG
Mould	NG	NG	NG	NG
Yeast	NG	NG	NG	NG

3.7. Sensory Evaluation

The sensory scores of nutrient-rich cookies are depicted in Table 6. According to the results presented, there was a significant increase in taste and overall acceptability of flours (Amaranth flour, Foxnut flour, and Wheat flour) composite cookies. No significant change was observed in the color, flavor, and texture of cookies prepared from a blend containing amaranth flour and foxnut flour. In terms of taste, a significant increase in mean scores was noted up to 87-90% addition of amaranth flour and foxnut flour into the composite cookies.

Table 6: Result of sensory evaluation of nutrient-rich cookies

Treatments	Color	Texture	Flavor	Overall Acceptability
T0 (Control)	8	7.83	7.83	7.88
T1	7.66	7.66	7.16	7.49
T2	8.33	8	8	8.10
T3	8.33	7.66	7.66	7.94



The overall acceptability score indicated that the cookies prepared with up to 87-90% amaranth flour and foxnut have the most acceptable sensory attributes. Sample T2 had a height score (of 8.10), while sample T1 had the lowest score (7.49) for overall acceptability. The additionalamount of butter is affected on cookies' aroma/flavor.This was

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contradicting the result which revealed that the cookies containing amaranth seed flour and foxnut flour were found to be most acceptable by the panelists.

The incorporation of protein-rich amaranth and foxnut flour into whole-wheat cookies resulted in better taste and aroma scores. Sample T1 had the lowest values of 7.66, and 7.16 for color, and flavor, while sample T2 had the highest scores of 8.33, and 8 for color, and flavor. Also, sample (T1) is the lowest value in texture as compared to sample (T2).

The scores for texture (softness and smoothness) and crunchiness (chewability) of the cookie samples were affected by amaranth and foxnut flour substitution. The cookie with (1:2:4) amaranth flour and foxnut flour substitution (sample T2), had the best score (8) for texture (softness, smoothness, and crunchiness). A hard crumb that is associated with increased fiber was probably mellowed by the oil contents. (Bakke and Vickers, 2007). The shortening (butter) is most affected bythe texture of cookies, a high amount of butter makesthe soft and smooth cookies. Cookies sample T2 is the best overall acceptable rating of 8.10.

IV. CONCLUSION

According to the results presented above, T2 was determined to be the most effective treatment out of all the formulations that contained varying concentrations of amaranth flour, foxnut flour, wheat flour, butter, sugar, baking soda, and baking powder. Contains 2.35% moisture, 2.01% ash, 8.36% protein, 25.38% fat, 61.9% carbs, 4.21% dietary fiber, 140.81 mg/kg iron, 25.68 mg/kg zinc, 1655.35 mg/kg potassium, and 318.93 kcal of calories. T2 formulation came out to be nutrient rich. Making nutrient-dense cookies can offer an adequate supply of all macro and micronutrient values. It might be beneficial to human health in terms of people suffering from malnutrition as well as those who lack nutrients in their daily diet. Nutrient-rich cookies were protein, iron, and potassium-rich as compared to market cookies (Unibic Cookies).

According to this study, foxnuts and amaranth flour are superior to wheat flour in terms of protein, fiber, and fat content. Positive changes in the physical features of the amaranth and foxnut-enriched cookies included a decrease in bake loss, an increase in diameter, a greater spread ratio, and lessened hardness, which resulted in the softer eating qualities that cookies call for. The sensory qualities of the amaranth-formulated cookies, up to 87-90%, were favorably received. Therefore, the combination of foxnut flour and amaranth flour in cookies proved successful in enhancing their technical and nutritional benefits. And nutrient-rich cookies are most beneficial for iron deficiency in humans. Cookies are beneficial for the most prevalent nutritional deficit worldwide is iron insufficiency. Young infants, expectant women, and menstruation women who lose iron are most likely to experience itduring their lunar cycles. Blood tests make it simple to determine one's iron level. Anemia can come from low iron levels. Hence these cookies are eaten an all generations of people. These cookies were not preferable for celiac disease patients and diabetic patients because in that cookies gluten as well as sugar is present.

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