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Assessment of amaranth flour utilization in cookies production and quality

Simona Man[1], Adriana Păucean[*1], Sevastiţa Muste[1], Maria-Simona Chiş[1], Anamaria Pop[1], Ioana-Daniela Călian (Ianoş)[1]

[1] *University of Agricultural Sciences and Veterinary Medicine, Faculty of Food Science and Technology 3-5 Mănăştur street, 3400, Cluj-Napoca, Romania*

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Abstract

Amaranth is an easy to grow, nutrient rich and underutilized pseudo cereal that can play an important role in actions against hunger and malnutrition that occur due to low rainfall conditions. This study aimed to asses the effect of the whole amaranth flour incorporation at different levels (30%, 50%, 70% and 100%) on the quality characteristics of cookies. The cookies were evaluated for physical (thickness, diameter, spread ratio, and weight), chemical, and organoleptic attributes. The results showed that the thickness, ash, fiber and the protein contents of the flour blend cookies increased with increasing levels of amaranth flour. Sensory evaluation showed that above 50% amaranth substitution levels, the scores for overall acceptability and sensory qualities decreased steadily. Cookies prepared from the blends of 50% wheat flour and 50% amaranth flour were appreciated by panelists as the most acceptable.

Keywords: cookies, whole amaranth flour, sensory evaluation, chemical composition

1. Introduction

Amaranth (*Amaranthus*) is an annual plant whose name derives from the Greek. Amaranth belongs to *Amaranthaceae* family which consists of hardy, weedy, herbaceous and fast growing cereal like plants [1]. The *Amaranthus* sort is cultivated most frequently in regions such as: Mexic, Central America, India, Nepal, China, East Africa [2] but is also cultivated in Romania. The results obtained in the production of *Amaranthus* sp. seeds, cultivated in the climatic and pedological (pedoclimatic) conditions from Jucu experimental field (Cluj County - Romania), present an average of 2,530.36 kg/ha, variants which provide a density of 100.000 plants/ha [3]. Other Amaranth cultures have been studied in the conditions of Teius Experimental Field (Alba County - Romania).

Amaranth species have become interesting to researchers of nontraditional agricultural plants due to their unique properties.

They are a potentially important source of bioactive chemicals used in food and pharmaceutical industries [4]. Amaranth is one of those rare plants whose leaves are eaten as a vegetable while the seeds are used as a cereal. Amaranth is a gluten free cereal and due to the increasing demands of gluten free products amaranth can be used in bakery products [1]. It is also used for processed food, as breakfast cereals, biscuits, cookies, and also as flour without gluten [5, 2].

In Asia, the diet finds in amaranth grain a culinary acceptable high protein, high fiber, alternative to wheat, and easy to incorporate into the traditional cuisine [6, 7]. Along with nutritional benefits, many health benefits are attributed to amaranth seeds, such as decreasing plasma cholesterol levels, stimulating the immune system, antitumor activity, reducing blood glucose levels, and improving conditions of hypertension and anemia [8, 7].

Corresponding author: *e-mail:* adriana.paucean@usamvcluj.ro

Cookies hold an important place in snacks due to their taste, crispness, and eating convenience. These are popular among all age groups especially in children. Generally, cookies are prepared from wheat flour, which are deficient in some essential amino acids like lysine and tryptophan, [7] whereas amaranth grains are rich in lysine and tryptophan [9]. To increase its nutritive value, cookies are prepared with fortified or composite flour [7].

Amaranth affords new perspectives due to its abundance in regard to bio- and techno-functional substances and its lack of allergenic proteins like gluten [31]. It has a variable applicability in pastry food like cookies, biscuits, cakes but also bread [20] increasing the product's nutritional values and raising protein, dietary fibre, minerals and fat contents, according to [7, 23, 10] and [26].

Amaranth seeds with their phenomenal nutritional profile provide several important nutrients that are often difficult to incorporate into a restrictive diet. The seeds contain large amounts of dietary fiber, iron, and calcium. They also have high amounts of lysine, methionine and cysteine, combined with a fine balance of amino acids, making them an excellent source of high quality, balanced protein, which is more complete than the protein found in most grains. In addition to its outstanding nutritional value, amaranth is also very low in sodium and contains no saturated fat [10].

Amaranth (*Amaranthus* L.) has also stronger radical scavenging ability than other cereals due to the presence of various antioxidants; phenolic compounds such as anthocyanins and flavonoid glycosides [11, 12].

The amaranth proteins have a good digestibility, a majority of proteins belonging to the group of water-soluble albumins and salt-soluble globulins [13, 14]. Although the properties of amaranth proteins have been studied by several researchers, only few data are available in the literature on the functional properties of different protein fractions of this crop [15, 16] and [7]. In addition, different methods have been used under different conditions which make the comparison and evaluation of the research data difficult. Bakeries belong to the group of food producers interested in the use of protein preparations with the aim to increase the nutritive value of breads and introduce new specialty breads without negatively influence quality parameters of the baked goods [18].

In view of the nutritional and agronomic benefits of amaranth, cookies were prepared from the composite flour containing various proportions of the whole amaranth flour. The purpose of this study was to determine the physicochemical and sensory attributes of amaranth flour-substituted cookies.

2. Materials and Methods

2.1. Materials

The experimental studies were carried out in laboratories of the Department of Food Products Engineering, Faculty of the Food Science and Technology, University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca. The raw materials used in these experiments: wheat flour (WF), amaranth flour (AF), hazelnuts, nuts, stevia powder (*Hyper-Stevia Rebaudiana*) and baking powder have been purchased from markets of specialized stores. The plastic container made from high density polyethylene bags was procured from the local market. The methodology adopted is described below.

2.2. Experimental plan and production of the cookies

Table 1 shows the ingredients used in the preparation of cookies (in g) and Figure 1 the flow chart for the cookies preparation.

2.3. Sensory analysis of cookies

Cookies were evaluated for overall acceptability (texture, colour, taste, odor and aroma) and the sensory evaluation was carried out as per 9 point Hedonic scale; the panel was formed by ten semi trained judges, faculty's students and staff, with ages between 22-46 years old.

2.4. Physical evaluation of cookies

Cookies diameter was measured by placing 6 cookies edge-to-edge to get the average diameter in millimeters. Cookie thickness was measured by stacking 6 cookies on top of each other and gets the average thickness.

Diameter: The diameter was measured in mm by Vernier caliper.

Thickness: The thickness was measured in mm by screw gauge.

Spread ratio: The spread ratio was determined by using this formula

$$Spread\,ratio = \frac{diameter(mm)}{thickness(mm)}$$

2.5. Chemical characteristics of cookies

Moisture, ash and fat content were determined according to Romanian STAS 1227-3/1990 [34]. Protein content was determined as per [35]. Kjeldhal Method, protein content was obtained by using the conversion factor of 5.7.

The total fibers were determined by the gravimetric method according to the [36], and total carbohydrate (%) content was calculated as the difference: 100-(moisture + ash + proteins + lipids + total fiber).

2.6. Statistical analysis

Data obtained were statistically analyzed by using Duncan multiple comparation test, according to [19].

Table 1. Recipe for making cookies from wheat flour and whole amaranth flour

Raw materials and auxiliary, kg	% wheat flour and amaranth flour			
	WF:AF V1(70:30)	WF:AF V2(50:50)	WF:AF V3(30:70)	WF:AF V4(0:100)
Wheat flour	70	50	30	0
Amaranth flour	30	50	70	100
Hazelnuts	35	35	35	35
Nuts	50	50	50	50
Stevia powder	3	3	3	3
Baking powder	2	2	2	2
Water	60	65	70	80

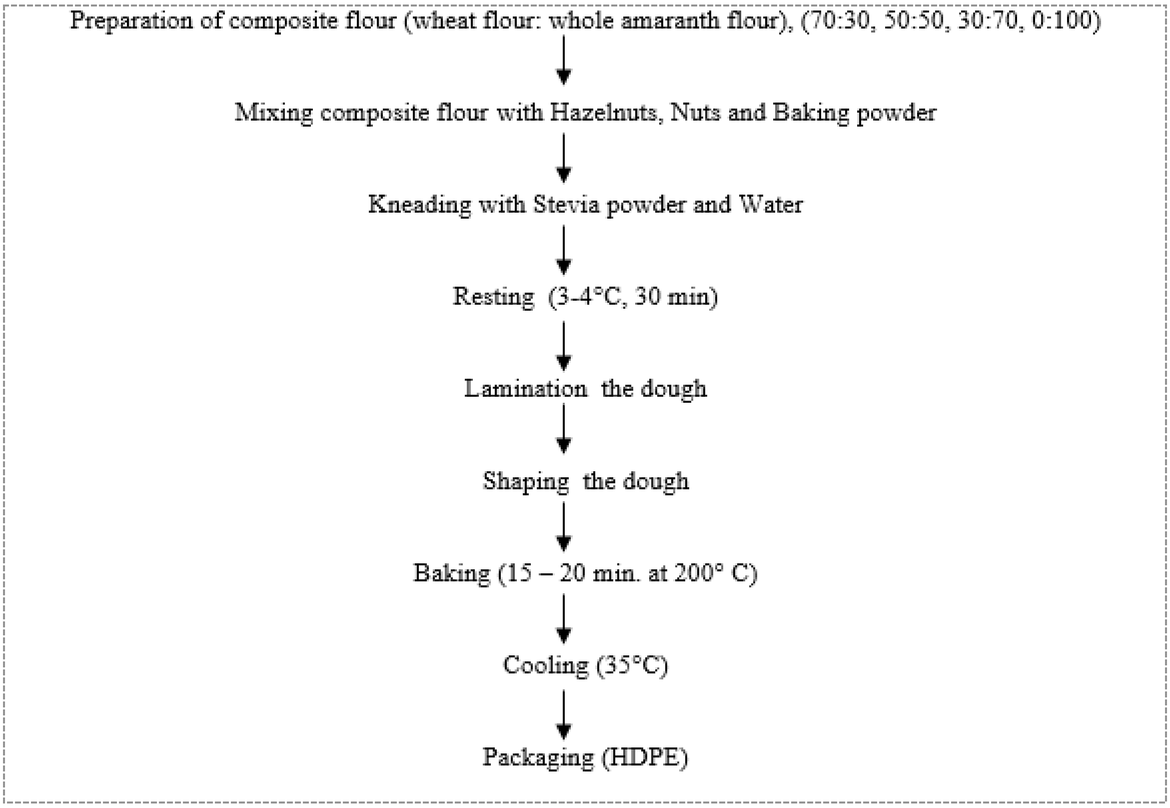

Figure 1. Cookies technological flow

3. Results and Discussion

3.1. Sensory evaluation for cookies

Sensory analysis was carried out by using untrained panelists to measure sensory characteristics like senses of sight, smell, taste, touch and acceptability of food product.

Mean score for sensory evaluation of cookies given in Table 2, revealed that there are significant differences between treatments for sensory attributes like taste, colour, flavor, texture and overall acceptability only for cookies prepared from the blends over 50% wheat flour and 50% amaranth flour.

Table 2. Sensory scores of prepared cookies using different blends (WF:AF)

Treatments	Colour	Texture	Taste	Flavor	Overall Acceptability
V1	$8,8^{b}$	$8,5^{c}$	8.6^{c}	8.9^{c}	8.7^{c}
V2	$8,6^{b}$	8.1^{bc}	8.3^{c}	8.5^{c}	8.4^{c}
V3	8.5^{b}	8.0^{b}	7.4^{b}	7.2^{b}	7.5^{b}
V4	7.9^{a}	$7,2^{a}$	6.6^{a}	5.9^{a}	6.9^{a}

*V1 = 70% wheat flour +30% amaranth flour; V2= 50% wheat flour +50% amaranth flour; V3 = 30% wheat flour +70% amaranth flour; V4 = 0% wheat flour +100% amaranth flour. *All analyses were made in triplicate and mean value was recorded*
** Values with different superscript in same column are significantly different

Table 3. Physical properties of cookies

Cookies Samples	Diameter (mm)	Thickness (mm)	Spread ratio	Weight (g)
V_1	40.20^{a}	12.0^{d}	3.35^{a}	8.42^{a}
V_2	40.30^{a}	11.0^{c}	3.66^{b}	8.72^{b}
V_3	40.20^{a}	10.0^{b}	4.02^{c}	9.16^{c}
V_4	40.20^{a}	9.50^{a}	4.23^{d}	9.46^{d}

*V1 = 70% wheat flour +30% amaranth flour; V2= 50% wheat flour +50% amaranth flour; V3 = 30% wheat flour +70% amaranth flour; V4 = 0% wheat flour +100% amaranth flour. *All analyses were made in triplicate and mean value was recorded*
** Values with different superscript in same column are significantly different

Table 4. Chemical parameters for cookies

Treatments	Moisture (%)	Ash (%)	Protein (%)	Fat (%)	Total fibers (%)	Total carbohydrate (%)
V1	7.12^{a}	3.90^{a}	18.67^{a}	29.5^{a}	4.7^{a}	36.11^{d}
V2	7.41^{b}	3.96^{b}	19.71^{b}	30.0^{b}	5.8^{b}	33.12^{c}
V3	7.73^{c}	4.55^{c}	22.52^{c}	30.6^{c}	6.4^{c}	28.20^{b}
V4	8.24^{d}	5.95^{d}	24.30^{d}	31.2^{d}	7.1^{d}	23.21^{a}

*V1 = 70% wheat flour +30% amaranth flour; V2= 50% wheat flour +50% amaranth flour; V3 = 30% wheat flour +70% amaranth flour; V4 = 0% wheat flour +100% amaranth flour. *All analyses were made in triplicate and mean value was recorded.*
** Values with different superscript in same column are significantly different

According to [18], the nutritional properties and also physical and sensory properties of the new product, could be influenced by the addition of new raw materials or by the replacement of traditional ones.

There was significant difference ($p \geq 0.05$) in colour between the samples V1, V2, V3 and V4 that could be explained by the increment addition on amaranths flour. Our results are similar to that reported by [18] and by [7] which suggested that the replacement of wheat flour with amaranth flour had influence on the colour bread. Also, [10] reported that the bread darkness is influenced by the high score of amaranth flour. There was no significant difference ($p \leq 0.05$) in texture among the cookies made from 30%, 50% and 70% amaranth flour (Table 2) but cookies made from 100% amaranth flour (V4) had significantly higher value than V1. The reduction of gluten in cookies dough by substituting with amaranth flour resulted in retarding the formation of gluten matrices, which contributed to the substantial decrease in texture. Chauhan A. et al. [7] showed that the force required to break the cookies significantly decreased with the addition of amaranth flour in cookies. Also, the absence of gluten in amaranth flour could influence the normal development of the dough, with influence on the final product texture, as reported by [5].

There was a significant difference ($p \geq 0.05$) in taste between V1 and V3, V4, that could be explained by the bitter aftertaste of amaranth flour. Our results are similar to the results reported by [7]. There was no significant difference ($p \leq 0.05$) in taste between the samples V1 and V2. The sensory score for flavor decreases after 50% addition of amaranth flour. This may be because the unusual nutty flavor of amaranth was pronounced as the percentage increased. Our results are similar to [10]. Valcárcel-Yamani B. et al. [20] mentioned that replacing wheat flour with 10% amaranth flour had a good influence on the flavor and the bread was preferred over the flavor of the white bread control.

The overall acceptability score indicated that there is no significant difference ($p \leq 0.05$) between the cookies prepared with 30% and 50% amaranth flour which had the most acceptable sensory attributes. However there was significant difference ($p \geq 0.05$) in taste, flavor and overall acceptance in amaranths biscuits prepared with 70% amaranth flour +30% wheat flour. The consumer's preference for cookies with up to 50% amaranth flour is also due to the addition of hazelnuts and nuts, which are recognized as having good improvement in taste and flavor's terms.

3.2. Physical analysis of cookies

The result of the physical analysis of the functional cookies produced from wheat flour (WF) and amaranth flour (AF) blends is shown in (Table 3), which shows that the mixing the flours in different percentages (WF and AF) has a significant effect on thickness, spread ratio and weight of cookies.

From the results, it was noticed that the weight of cookies increased as the proportion of amaranth flour content increased. This could be explained by higher protein content of amaranth flour compared to wheat flour, which involves higher water holding capacity of amaranth flour as described by [7, 10] and [21].

The cookie diameter increased as the amount of amaranth flour increased, having significant difference ($p \geq 0.05$) between V1, V2, V3, V4 samples. This result may be justified by lower viscosity of amaranth flour than wheat flour which means that the viscosity of dough is reduced by the addition of amaranth flour. The spread ratio values increased as the addition of amaranth flour increased. This result can be explained by the increase of spread ratio with the addition of non-wheat protein content, according to [7].

3.3. Chemical analysis of cookies

There was a significant difference ($p \geq 0.05$) in moisture, ash, protein, fat, total fibers and total carbohydrate between V1, V2, V3, V4 samples, (Table 4). The amaranth flour absorbed more water than the wheat flour during dough making and this was explained by the presence of larger amounts of crude fiber in the amaranth flour, which tended to imbibe and retain more water in the dough, according [2] and [21]. Also, the water absorption could be influenced by the extremely small granules of amaranth flour and its unique structure (dodechadral) which encourage water absorption [5].

The ash content increased with the addition of amaranth flour, justified by the high ash content of amaranth flour (2.5 - 4.1%), compared to wheat flour as reported by [20, 18, 23] and [5]. Similar results were also obtained by [23] that mentioned that replacing wheat flour with 40% amaranth flour in order to obtain bread, increased the ash content of bread from 1.35g/100g at 2.06 g/100g.

Amaranth seeds are known because of their protein content which is bigger than the wheat flour, as reported by [24] and by [22]. Amaranth seed is high in protein (17%) and its amino acid has an optimum balance, close to the human needs [25]. As the amaranth flour content increased, the amount of protein in the cookies increased, due to the high protein content of amaranth flour. Lemos Ados R. et al. [26] showed that replacing wheat flour with 10% amaranth flour increase with 17% the protein content, 18 times the amount of dietary fiber and triple the amount of iron.

The fat content of amaranth flour is 5,4%, result in agreement with other studies [7] and [20]. The high fat content of cookies could be explained by the fat content of amaranth flour, but mostly by the nuts and hazelnuts fat content which is reported between 42-67% mainly composed of mono- and polyunsaturated fatty acids (>75% of the total lipids), according to [27].

The total dietary fiber content increased from 4.7 to 7.1%, with the addition of amaranth flour. This increase is due to the chemical composition in dietary fiber of amaranth flour. The amaranth flour has a high total dietary fiber content of 9,83g/100g, having soluble dietary fiber content of 4,29 ± 0.12, and insoluble dietary fiber content of 5.54 ± 0.14, as reported by [33]. This result is in line with [23], the difference could be explained by the chemical composition of nuts and hazelnuts, which constitute a good source of total dietary fiber, as shown in [28, 29] and [30].

Total carbohydrate decreased as the amaranth flour increased, due to the high content in protein, fat, total fiber, lipid, moisture of amaranth flour, resulting a final product enriched in all these bioactive compounds. The difference method used to determine total carbohydrates of bakery products is reported also by [32].

4. Conclusions

Amaranth flour could be used as a replacement for wheat flour in order to prepare cookies, increasing the content of protein, total dietary fibre, fat, ash, having an optimum proportion of 50g/50g, which preserve not only the nutritional benefits, but also the product quality.

Due to the lack of gluten, it's colour and nutsy flavour, the bitter aftertaste, amaranth flour used in blend with wheat flour over 50% has a negative influence of the texture, colour, on the taste and flavour of the final product, which means that it must be used in certain proportions in order to keep the same product quality.

Compliance with Ethics Requirements.

Authors declare that they respect the journal's ethics requirements. Authors declare that they have no conflict of interest and all procedures involving human / or animal subjects (if exist) respect the specific regulation and standards.

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