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Physico-Nutritional and Sensory Properties of Cookies Formulated with Quinoa, Sweet Potato and Wheat Flour Blends

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Abstract

The study was conducted to formulate cookies with and without partial replacement of wheat flour (W) with sweet potato (SP) and quinoa flour (Q) blends. Sweet potato flour and quinoa flour were blended in equal proportion and then incorporated at the levels of 20, 40 and 60% by replacing wheat flour to prepare cookies. The cookies formulations were: CI (Control, 100W), CII (80W+10Q+10SP), CIII (60W+20Q+20SP) and CIV (40W+30Q+30SP). The three flour types and the prepared cookies were accessed for their nutritional properties. The prepared cookies were also evaluated for their physical parameters and sensory characteristics. The nutritional profile of cookies increased with increased level of addition of sweet potato and quinoa flour. The protein, fat, fibre and ash content of cookies prepared with 60% replacement of wheat flour with sweet potato and quinoa flour blend were found to be 29.3, 71.6, 51.8 and 108.3% respectively, higher than those of control cookies. The spread ratio and the thickness of cookies decreased with the addition of blended flour of sweet potato and quinoa. All the cookies were found acceptable on the hedonic scale in terms of appearance, colour, texture, flavour, taste and overall acceptability. The CII cookies were most preferred by the sensory panel with overall acceptability score of 7.8, only next to control cookies (CI) with a score of 8.

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Introduction

Nowadays the demand for nutritionally rich products is increasing among consumers. These products are categorized by high fibre content, high and good quality protein content, etc. At the same time industry is striving to formulate functional products which are less expensive, readily available, and should have satisfactory functional and sensory properties.[1] Cookies or biscuits refer to a baked product which mainly contains flour (generally wheat

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flour), fat, shortening, sugar and salt. The cookies are convenient, ready-to-eat snack which is consumed world-wide. Cookies also offer a great way of blended flour replacements, and thus an easy and suitable way of improving nutrition.[2] In recent years, there is an increased awareness among consumers for the consumption of whole cereals which are gluten-free and have high fibre and high protein contents. Therefore, various studies have evaluated the use of composite flours, from cereal, psedocereals and root crops, as a replacement to wheat flour in cookies and other functional products development. Along with the advantages of these composite flours the challenge is to achieve acceptable physical and sensory properties of the formulated products.[2,3] Cookies with good sensory scores have been produced from blends of millet, rice, greengram, bengalgram, chickpea, groundnut, cowpea, quinoa, etc.[3,4]

Quinoa, unlike wheat, rye, barley, does not contain gluten thus can serve as is important alternative to traditional cereals, for people suffering from Celiac disease. Quinoa is a pseudo-cereal and belongs to the genus *Chenopodium (Chenopodiaceae* family). It is an ideal grain whose protein profile resembles that of milk with the added advantage of being high in essential fatty acids and fibre.[4] Quinoa is a very rich source of some important minerals like calcium, magnesium, iron and zinc.[5] Quinoa is being used in the products like bread, chips, pancakes, and cookies and gaining consumer acceptance worldwide.[6]

Nowadays, there is an increase in the population suffering from several food related intolerances. The most popular of these are lactose intolerance, gluten intolerance/gluten allergies and celiac disease. For the gluten intolerance patients, buckwheat, amaranth, quinoa are the three pseudo-cereals which can be incorporated into diets.[7] The pervasiveness of cardiovascular diseases and other degenerative diseases like cancers are also on rise and integration of whole psedo-cereals like quinoa, which has functional properties, into the diet might help provide a safe, easy and economical way of prevention against such diseases.[4] Thus quinoa cookies can also prove as a good alternative for the health conscious people. However, only a limited substitution of wheat flour with quinoa flour is possible because of low dough forming and baking quality of quinoa flour because of absence of gluten in it.[8]

Sweet potato is one of the main food crops in the world and India has a long history of cultivating and consuming sweet potatoes.[9,10] Sweet potatoes can be grown in a variety of soil and climatic conditions and have a short growing cycle thus can serve as a potential food as well as food ingredient in the developing nations. It can be used to make dry chips, baked chips, stew, and flour which could be used in baked products.[11] Sweet potato flour is an excellent source of complex carbohydrates, dietary fibre, pro-vitamin A and minerals like potassium, calcium, iron and phosphorous.[12,13]

The specialty products or functional products which are naturally low in gluten can serve as a good alternative to traditional snacks for the health conscious people and to the patients who can only handle only a low amount of gluten in diet. Quinoa and sweet potato can be explored as two non-traditional gluten-free ingredients which have high nutritional content, superior amino acid profile, rich in vitamins, mineral and antioxidants. Cookies are one such product which is a convenient snack and has liking worldwide. Thus quinoa and sweet potato can be evaluated as wheat flour replacements in cookies.

The present study was undertaken to study the preparation of cookies from sweet potato and quinoa flour blends as partial replacement to wheat flour and to determination the physico-nutritional characteristic, physical properties and sensory attributes of the formulated cookies.

Materials and Methods

Quinoa flour, wheat flour and all other ingredients required in cookies preparation were purchased from local market of Amritsar, Punjab, India. Sweet potato was procured from local market and was processed into flour following standard procedure.[14] The sweet potatoes were washed and peeled and then sliced to approximately 1 cm thickness. The slices were then dried in cabinet drier at 70^0C for 5-6 h (till the weight becomes constant). The slices were cooled and ground using Newport Scientific Super Mill (Newport, Australia). The flour is sieved through

70 mesh screen and stored in high density polyethylene (HDPE) till further use.

Cookies Formulations and Preparation

Four different types of cookies formulations were prepared with and without partial replacement of wheat flour with sweet potato and quinoa flour as per detail given in Table 1. The Cookies of all formulations were prepared according to standard method.[15] Various ingredients like wheat flour, sugar, sodium bicarbonate, cardamom essence, shortening, margarine (low cholesterol butter) were creamed together in Hobart mixer (Model N50, Canada), having flat beater blades, for 6 min at 60 rpm. After proper mixing, egg albumin was added for proper dough formation. The total time taken for mixing was 7-8 min to obtain a homogenous mixture. Egg albumin is used as a replacer of water in this method. After the batter was properly mixed then batter was sheeted to a thickness of 7 mm at the cookie table. The diameter of cookie cutter was 4.5 cm. Baking oven was pre heated at 180 °C and cookies were baked at the set temperature for 10 min. Baked cookies were then cooled for 1-2 min and stored in an air tight container for further analysis.

The cookies formulated were as follows:
100% Whole wheat flour (100W, CI),
80% Whole wheat flour+10% Quinoa flour+10% Sweet potato (80W+10Q+10SP, CII),
60% Whole wheat flour+20% Quinoa flour+20% Sweet potato (60W+20Q+20SP, CIII),
40% Whole Wheat flour+30% Quinoa flour+30% Sweet potato (40W+30Q+30SP, CIV).

Table 1: Formulation and composition of cookies from whole wheat, quinoa and sweet potato flours

Ingredients (g or ml)	CI	CII	CIII	CIV
Whole wheat flour	100	80	60	40
Fat	35	35	35	35
Sugar	55	55	55	55
Sodium bicarbonate	1.14	1.14	1.14	1.14
Shortening	2.5	2.5	2.5	2.5
Cardamom essence	1.5	1.5	1.5	1.5
Egg albumin	20	20	20	20
Quinoa flour	-	10	20	30
Sweet potato flour	-	10	20	30

Proximate Analysis of Raw Material and Formulated Cookies

The proximate composition of formulated cookies was analyzed by AOAC official methods of analysis.[16] The quinoa flour, sweet potato flour, wheat flour and the formulated cookies were analysed for: moisture content using hot air oven single stage method (130^{0}C for 1 hr), fat by Soxhlet solvent extraction method, protein by micro-Kjeldahl method (N x 6.25), crude fibre by gravimetric method and ash content by dry ashing method. Carbohydrate content was determined by difference method [Carbohydrate (%) = 100 – (Moisture% + Fat%+ Protein% + Crude fibre% + Ash%)]. Three replicate experiments were conducted to determine each compositional parameter and their mean ± standard deviation were reported.

Physical Characteristics of Formulated Cookies

Cookie Thickness

The cookies were allowed to cool for approximately 30 min after baking. Then, six cookies were placed one over the other on a tray and the total height was measured with a vernier caliper then the reading was divided by 6 to get the thickness of one cookie. The procedure was repeated two more times to get the replicate readings. The average thickness and its standard deviation were calculated and reported in cm.

Cookie Diameter

The diameter of cookie was measured with vernier caliper. The cookie was then rotated through 90º and was re-measured for diameter in cm. Three replicates of readings were taken and their average and standard deviation were calculated.

Cookie Spread Ratio

The spread ratio was obtained by dividing the diameter of the cookie with its thickness. It gives an indication of the quality. The average and standard deviation of three replicates were reported.

Sensory Evaluation

Sensory evaluation consisted of judging the quality of prepared cookies by a panel of ten semi-trained panellists. The evaluation deals with analysing the overall sensory quality of cookies as perceived by the sense of sight, taste, and touch. A hedonic scale rating test was used to measure the degree of pleasurable and un-pleasurable experience of cookies on a scale of 9 points from "like extremely" to "dislike extremely". The panellists were given an evaluation form which listed various sensory parameters and score options with number rankings. When all the evaluation forms were complete, the data were averaged and tabulated. The cookies were rated for their sensory attributes like taste, texture, colour, appearance, and overall acceptability.

Statistical Analysis

The triplicate readings of physico-chemical properties of three flours used and formulated cookies as well as physical properties of cookies were analysed using analysis of variance (ANOVA) at ($P<0.05$) along with Duncan's multiple range test using statistical software (SAS version 9.1, Inst. Inc., Cary, N.C., U.S.A.).

Results and Discussion

The wheat, sweet potato and quinoa flours were evaluated for proximate composition and used in the formulation of cookies. The cookies were formulated with and without the addition of sweet potato and quinoa flour blends at the levels of 20, 40 and 60% and were evaluated for their physical, physico-chemical and sensory attributes.

Proximate Composition of Raw Material

The moisture, ash, fat, protein and crude fibre content of quinoa, sweet potato and wheat flours were determined (Table 2). Wheat flour showed the highest moisture content (14.22%) followed by sweet potato (12.90%) and quinoa flour (10.93%). The fat and crude fibre content was also highest in the quinoa flour. The fat content of quinoa varied between 2.0% -9.5% and most of the fat comprised of healthy alpha-linoleic and linoleic fatty acids which cannot be synthesized by the body itself and need to be taken from a food source.[6]

The protein content was the highest in quinoa flour (13.50%) and lowest in sweet potato flour (5.88%).A research found the protein content in quinoa to vary from 13.8% to 16.5%[17]. Quinoa has a high protein content and has a unique distribution of essential amino acids.[18] According to a United States Department of Agriculture (USDA, 2011) report, protein content was found to be the highest in quinoa (16.3%), followed by wheat (14.8%), sorghum (12.4%), rye (11.6%), barley (11%), corn (10.5%) and rice (8.8%).[4]

The ash content was found to be highest in the sweet potato flour as compared to wheat flour and quinoa flour which can be due to the high mineral concentration in the sweet potatoes.[12]

Proximate Composition of Cookies

The formulated cookies were analyzed for their moisture, protein, fat, fibre and ash content (Table 3). The nutritional parameters like protein, fat and fibre showed an increasing trend with a higher replacement of wheat flour with a blend of sweet potato and quinoa flour. This may be attributed to the superior nutritional profile of quinoa and sweet potato as compared to wheat flour. The moisture content of cookies formulated with quinoa flour and sweet potato flour with 20%, 40%, and 60% level of replacement of wheat flour varied significantly from each other and ranged from 12% (wb) to 16.8% (wb). Among different concentration, cookies with 60% replacement shows the highest moisture content of 16.8%, followed by 14.5% and 12.2% for cookies with 40% and 20% replacement, respectively.

Moisture content of cookies increased with increased proportion of quinoa flour and sweet potato flour which may be due to high protein (13.5%) and fibre content (9.5%) of quinoa flour and high fibre (5.55%) content of sweet potato flour. A study reported that the moisture content of baked products increased proportionally with the increase in their protein content.[19] In another study, an increase in moisture content with increased proportion of sweet potato was reported which can be due to the high fibre content of sweet potato thus higher water holding capacity.[12]

Table 2: Proximate composition of quinoa, sweet potato and wheat flour

Parameters Flour	Quinoa Flour	Wheat Flour	Sweet potato
Moisture (%)	$10.93^{c} \pm 0.03$	$14.22^{a} \pm 0.07$	$12.90^{b} \pm 0.02$
Ash (%)	$1.13^{c} \pm 0.07$	$1.23^{b} \pm 0.02$	$2.09^{a} \pm 0.02$
Fat (%)	$1.91^{a} \pm 0.02$	$1.73^{b} \pm 0.01$	$1.49^{c} \pm 0.01$
Protein (%)	$13.50^{a} \pm 0.01$	$10.65^{b} \pm 0.01$	$5.88^{c} \pm 0.01$
Crude fibre (%)	$9.47^{a} \pm 0.04$	$0.59^{c} \pm 0.01$	$5.55^{b} \pm 0.03$

The readings are average of three replicates±SD. The values followed by the same alphabet within a row are not significantly different at P<0.05.

The protein content of cookies formulated with QF and SP with 20%, 40%, and 60% replacement of wheat flour varied significantly from each other and ranged from 12.9% to 14.61%. The protein content of whole wheat cookies was determined to be 11.3%. While amongst different levels of incorporation, formulation CIV shows highest protein content of 14.61% while formulation CII had lowest protein content of 12.9%. The protein content increased with the increasing level of replacement of wheat flour with quinoa and sweet potato flour due to higher protein content of quinoa flour than wheat flour. Researchers reported that the usual protein content of biscuits ranged from 5.60% to 7.20%.[18]

Table 3: Proximate compositions of cookies

Formulations	Moisture	Fat	Protein	Ash	Fibre
100W(CI)	12.2^{c}±0.07	17.6^{d}±0.01	11.30^{d}±0.01	1.2^{c}±0.02	0.54^{c}±0.05
80W+10Q+10SP (CII)	12.0^{c}±0.02	27.8^{c}±0.02	12.90^{c}±0.01	1.6^{b}±0.03	0.73^{b}±0.01
60W+20Q+20SP (CIII)	14.5^{b}±0.03	28.2^{b}±0.01	13.06^{b}±0.05	2.3^{a}±0.01	0.80^{a}±0.04
40W+30Q+30SP (CIV)	16.8^{a}±0.01	30.2^{a}±0.01	14.61^{a}±0.03	2.5^{a}±0.03	0.82^{a}±0.01

The readings are average of three replicates±SD. The values followed by the same alphabet within a column are not significantly different at P<0.05.

The ash content of cookies formulated with sweet potato and quinoa flour blends in different proportions varied significantly from each other. Amongst different levels of incorporation, formulation CIV showed the highest ash content of 2.5% followed by formulation CIII and CII with ash content of 2.3% and 1.6%, respectively. Cookies with 100% wheat flour (CI) formulation showed minimum ash content of 1.2% of all the cookies. The ash content of cookies increases with the increased incorporation of sweet potato and quinoa flour blend due to high ash content of sweet potato flour (2.09%) than that of wheat flour (1.23%).

The fat content of cookies formulated with sweet potato and quinoa flour having different composition varied significantly from each other. Fat content of cookies ranges from 27.8% to 30.2%. Among different addition levels, Formulation CIV showed the highest fat content of 30.2% followed by CIII (28.2%). Cookies with 100% wheat flour showed fat content of 17.6% which was lowest among all cookies. The increase fat content of cookies may have resulted from the high oil absorption and retention capacity of quinoa flour.[20] Higher oil retention capacity showed improved mouth feel and flavour of the cookies.[21] Moreover, quinoa is naturally rich in essential fatty acids.

The crude fibre content of cookies formulated with sweet potato and quinoa flour varied significantly and ranged from 0.54% to 0.82%. Amongst different levels of addition of sweet potato and quinoa flour, Formulation CIV (60% replacement of wheat flour) showed the highest crude fibre of 0.82% whereas formulation CII showed crude fibre content of 0.73%.High fibre contents of quinoa and sweet potato resulted in the increase in fibre content of cookies with highest level of replacement (60%) as compared with wheat flour cookies. Similar trends were observed for quinoa flour biscuits.[21]

Physical Properties of Cookies

The formulated cookies had the thickness ranging from 0.87 to 1.12 cm (Table 4). The thickness increased significantly ($P<0.05$) with the increased level of addition of flour blend of sweet potato and quinoa. Also the diameter of the cookies decreased, the diameters of blended flour cookies were significantly ($P<0.05$) smaller than that of 100% wheat flour cookies (CI). The spread ratio of the formulated cookies followed the decreasing trend with the increased level of replacement of wheat flour by sweet potato and quinoa flour blends, which was 5.29 for 100% wheat flour cookie (CI) and reduced to 4.05 for cookie with 60% blended flour (CIV). The variation in spread factor was more influenced by thickness of cookies than their diameter. Similar results were reported by Protonotariou *et al.,*[22] The spread ratio decreases with the addition of the flours which absorb more water than the wheat flour.[23] The quick binding of free water molecules by the hydrophilic sites of non-wheat flours or other ingredients can increase the viscosity of the batter thus resulting in cookies which spread less.[24]

Table 4: Physical properties of cookies

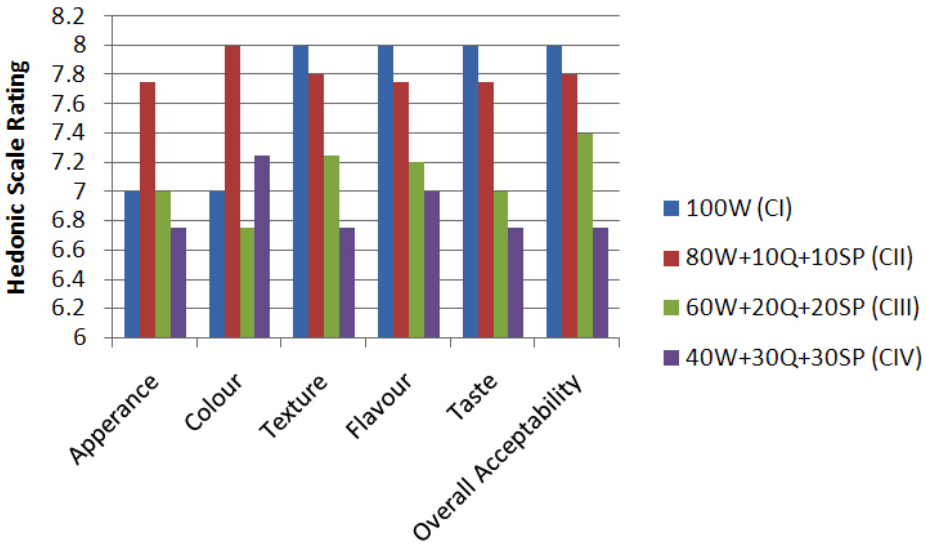
Formulations	Diameter (cm)	Thickness (cm)	Spread ratio
100W(CI)	$4.60^{a}\pm0.05$	$0.87^{c}\pm0.01$	$5.29^{a}\pm0.05$
80W+10Q+10SP (CII)	$4.50^{b}\pm0.04$	$0.95^{cb}\pm0.08$	$4.74^{b}\pm0.08$
60W+20Q+20SP (CIII)	$4.54^{ab}\pm0.01$	$0.99^{b}\pm0.01$	$4.59^{c}\pm0.02$
40W+30Q+30SP (CIV)	$4.54^{ab}\pm0.02$	$1.12^{a}\pm0.01$	$4.05^{d}\pm0.02$

The readings are average of three replicates±SD. The values followed by the same alphabet within a column are not significantly different at $P<0.05$.

Sensory Characteristics of Cookies

All the formulated cookies got the acceptable sensory scores for all the evaluated parameters (Fig. 1). The sensory scores were above 6.7 for all the prepared cookies, where a score of 6 represents "Like Slightly" on the hedonic scale. However, as the level of the addition of the blended flour (sweet potato and quinoa flour) increased in the formulations, there was a decrease in the hedonic scale rating for sensory attributes namely, taste, texture, flavour, and overall acceptability of cookies. This may be resulted because of the higher yellowness and high fibre content of sweet potato and a bland taste of quinoa, addition of these two are responsible for the deviation of the taste from that expected from the regular wheat flour cookies. For the above parameters the score of wheat cookies was the highest. Also, the appearance score was lower for the cookies with 40% and 60% replacements which is due to the unconventional colour (different from those of wheat cookies) and

due to the appearance of cracks on the surface of the cookies which may have resulted due to more gluten-free quinoa and sweet potato flours added in the cookies. In a study, the cookies made with the higher levels (>15%) of defatted wheat germ flour developed the crumbly texture and darker colour.[2] The score of flavour reduced significantly to 6.7 from 8 (for 100% wheat cookies) on the replacement of 60% wheat flour. It was possibly due to the presence of saponins present in outer layer of quinoa which was milled into the flour which have bitter taste.[25] The overall acceptability of wheat cookies (CI, control) was rated at level 8 on hedonic scale by the sensory panellists followed by 20% replacement (CII), 40% (CIII) and 60% (CIV) with the score of 7.8, 7.4 and 6.7, respectively. To launch a product in the market, usually a sensory score of at least 7 (like moderately) is required.[26]



The readings are mean of ten replicates.

Fig.1: Sensory evaluation of cookies formulated with replacement of wheat flour (W) with quinoa flour (Q) and sweet potato flour (SP) blends.

Conclusion

Sweet potato and quinoa are two such crops whose flours are nutritionally superior to the wheat flour and have functional properties. Therefore, in this study, different types of cookies were prepared with and without partial replacement of wheat flour using the equal blend of sweet potato flour and quinoa flour at 20, 40 and 60% levels. The cookies with 60% of sweet potato and quinoa blend had the highest protein, fibre, fat and ash content. With the increased level of the addition of blended flour in the cookies their diameter decreased (till 40% replacement) and the thickness increased and the resulting spread ratio also decreased. It may be concluded from the study that sweet potato and quinoa flour blends can be added in the wheat flour up to the level of 60% (or 30% each flour) to formulate cookies which are nutritional superior than the wheat cookies and will be acceptable to the consumers although the level of liking decreases with the increased level of blended flour replacement, the overall acceptability score was 8 for control (100% wheat) cookies and decreased to 6.7 for the cookies with 60% blended flours in them. The research and development of such functional foods will help to improve the nutritional profile and health status of people living in developing and under developed nations.

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Conflict of Interest

There is no conflict of interest.

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