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Evaluation of physical properties and sensory attributes of biscuits developed from whole wheat flour supplemented with horse gram flour

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Abstract
Horse gram is a popular traditional grain legume of Uttarakhand which remained underexploited due to its limited competitiveness to the commercial crops. However, it being a cheap source of protein and high in other nutrients and bioactive compounds brings it at par with the commonly grown pulses. Horse gram is highly suitable for commercial foods and its flour could be used in the preparation of various food products. But the non-availability of value added products from horse gram has been a major factor behind the limited utilization of this nutrient rich legume. Therefore, the present study was aimed at developing functional biscuits by incorporating horse gram flour to whole wheat flour and to determine the physical properties and sensory characteristics of horse gram flour biscuits. The biscuits were prepared by blending horse gram flour to whole wheat flour in ratios of 00:100 (control), 05:95 (T1), 10:90 (T2), 15:85 (T3), 20:80 (T4), 25:75 (T5) and 30:70 (T6) and were analysed for physical characteristics. The result showed that the physical properties viz. weight, diameter and thickness of biscuits decreased significantly (p<0.05) with the increase in the level of horse gram flour in the flour blend, while, the spread ratio increased insignificantly. Sensory evaluation showed that the biscuits developed by supplementing 25 per cent horse gram flour to whole wheat flour scored highest in terms of flavour, texture, taste and overall accepatability. Thus, it is evident from the study that horse gram flour may be successfully incorporated to develop highly acceptable value-added biscuits with improved nutritional value.

Keywords: Biscuits, horse gram, physical properties, sensory evaluation, whole wheat flour

Introduction
Legumes or pulses are dry edible seeds of plants belonging to the Fabaceae (*Leguminoseae*) family, which include field peas, dry beans, lentils, chickpeas and faba beans and many more (Bresciani and Marti 2019) [1]. Legumes are rich source of proteins, carbohydrates, dietary fibers many water-soluble vitamins, especially vitamin B complex, and minerals like calcium and iron (Sreerama *et al.*, 2012) [2]. The high fiber and protein content of legumes improves glycemic control, insulin sensitivity, maintain normal lipid levels decrease the occurrence of obesity and helps in managing body weight (Hodge *et al.*, 2007; Brunner *et al.*, 2008; McCrory *et al.*, 2010; Bazzano *et al.*, 2011) [3-6]. Consumption of pulses has been found beneficial in the management of type 2 diabetes, metabolic syndrome and protection against CVD and atherosclerosis (Leterme 2002; Bazzano *et al.*, 2001; Fung *et al.*, 2002; Nettleton *et al.*, 2010; Jenkins *et al.*, 2012) [7-11].
Horse gram (*Macrotyloma uniflorum*) is one of the lesser known and underutilized pulse crop grown in India. It is quite a popular legume, especially in southern Indian states such as Karnataka, Tamil Nadu, Andhra Pradesh, Northwestern Himalayan states and Uttarakhand. It consumed as a whole seed, as sprouts, or as whole meal in many parts of India. Horsegram is an excellent source of protein, carbohydrates, dietary fibre, micronutrients and bioactive compounds (Handa *et al.*, 2017; Pal *et al.*, 2016; Sreerama *et al.*, 2012; Sreerama *et al.*, 2012) [12, 13, 2, 14] and its nutritional composition is comparable to other more commonly cultivated legumes. The presence of complex carbohydrate and dietary fibre in horse gram contributes to its low glycemic index and helps in reducing the risk of heart disease, diabetes and obesity (Prasad and Singh, 2015) [15].
In the recent years, much emphasis has been put on extending the consumption and use of grain legumes as functional ingredients in various food applications without affecting the desirable properties and eating qualities of products (Ma *et al.*, 2011; Luliana *et al.*, 2012) [16, 17]. Among the ready-to-eat snacks, biscuits have always been popular due to their wider consumption base, easy availability, relatively long shelf-life, less cost, varied taste and good eating quality (Singh *et al.*, 1993; Gandhi *et al.*, 2001; Hooda and Jood, 2005) [18-20].

A number of research studies have been conducted to develop high protein and high fiber biscuits from wheat flour fortified with various legumes such as chickpea, pigeon pea, moong bean, and cowpea (Thongram *et al.*, 2016; Tiwari *et al.*, 2011) [21, 22], green lentils (Zucco *et al.*, 2011) [23], soybean (Farzana and Mohajan, 2015) [24], gram flour (Yousaf *et al.*, 2013) [25] and common bean (Sparvoli *et al.*, 2016) [26], but the information on the use of horsegram flour is scanty.

Horse gram flour has a great potential to be utilised in the development of commercial food products such as bakery products, or in form of composite flours as partial substitutes of chickpea flour in snacks, confectionery and other traditional food products (Sreerama *et al.*, 2012) [2]. But the non-availability of processed food products has restricted the usage and acceptability by consumers, despite its nutritional superiority. Blending of cereal flour with horse gram flour would also help to improve the nutritional value of the product in terms of increased protein, dietary fiber and other micronutrients. Therefore, there is a need of value-added ready-to-use products and functional foods to offer variety, convenience and quality to consumers as well as for revamping of horse gram cultivation. So, the study was conducted with the objective to develop biscuits from whole wheat flour supplemented with horse gram flour and to evaluate the physical and sensory characteristics of the biscuits.

Materials and methods

Source of raw materials

Horse gram (*Macrotyloma uniflorum*) VLG-19 variety was procured from Vivekananda Parvatiya Krishi Anusandhan Sansthan (VPKAS), Almora, Uttarakhand. The other food items viz. whole wheat flour, sugar, vegetable oil, baking powder, skimmed milk powder, sodium bicarbonate, ammonium bicarbonate and vanilla essence were purchased from local market of Pantnagar (Udham Singh Nagar), Uttarakhand, India.

Preparation of flour from horse gram

Horse gram seeds were sorted, cleaned, and thoroughly washed 3-4 times under running water and then dried in oven at 50°C for 5-6 hours. After cooling to room temperature, the seeds were ground in small capacity flour mill (Atta master) and sieved with 60 mesh size sieve. The horse gram flour thus obtained was stored in airtight container for further study.

Preparation of blends from whole wheat flour and horsegram flour

The whole wheat flour and horse gram flour were mixed in different ratios as shown in Table 1. The 100% whole wheat flour served as the control sample.

Table 1: Blending ratio of whole wheat flour and horsegram flours

Sample Code	Whole wheat flour	Horsegram flour
Control	100	0
T1	95	5
T2	90	10
T3	85	15
T4	80	20
T5	75	25
T6	70	30

Preparation of biscuits

The biscuits were formulated according to the recipe given by Whitley (1970) [27] with slight modifications. The ingredients used for biscuit making have been listed in Table 2.

Table 2: Experimental baking formula for biscuits

Ingredients	Amount
Whole wheat flour/blend	67 g
Sugar	13 g
Fat	17 g
Skimmed milk powder	1.5 g
Ammonium bicarbonate	0.5 g
Common salt	0.4 g
Baking Powder	0.3 g
Sodium bicarbonate	0.2 g
Vanilla	0.4 ml
Water	As required for proper consistency

The traditional creaming method was used for the preparation of biscuits. Fat and sugar were mixed in a mixer until the mixture became light fluffy. Into the mixture, composite flour and other ingredients i.e. skimmed milk powder, baking powder, ammonium bicarbonate, sodium bicarbonate and salt were added and all the components were mixed thoroughly. Water was added to the flour mixture and it was kneaded lightly to make a soft dough. The dough was rolled out into sheets using a rolling pin and cut into the circular shape of 6 mm thickness using a biscuit cutter. The cut mass was transferred to a greased baking tray and baking was carried out at 180 °C for 17 min. After cooling, biscuits were packed in high density polyethylene pouches, labeled and stored at ambient temperature for various determinations.

Determination of the Physical Characteristics of Biscuits

The physical properties of biscuits viz. weight, thickness, diameter and spread ratio were evaluated by the method described by AACC (1967) [28]. Weight of the biscuit was determined using a digital analytical weighing balance and recorded in grams. Diameter (W) of biscuits was determined by placing six biscuits edge to edge and measuring the total diameter in centimeter with the help of a measuring scale. The biscuits were rotated at an angle of 90° and their diameter was measured again to check the accuracy. Biscuit thickness (T) was measured by stacking six biscuits on top of each other, measuring the thickness using vernier caliper, restacking in a different order and remeasuring them to get the average thickness in centimeters. Spread ratio (W/T) was determined by dividing width (cm) by thickness (cm). The value for each parameter was recorded in triplicates.

Sensory Evaluation of Biscuits

Sensory evaluation of the biscuit samples was carried out for consumer acceptability and preference using fifteen semi-trained panelists from the Department of Foods and Nutrition, College of Home Science, G.B. Pant University of Agriculture and Technology. The biscuit samples were evaluated for colour, flavour, texture, taste and overall acceptability using score card method (Amerine *et al.*, 1965) [29].

Statistical analysis

For data entry and analysis Microsoft excel programme was used. Simple statistical tools such as mean, standard deviation (SD), standard error (SE) and percentages were calculated for all the parameters. The experimental data were statistically analysed for analysis of variance using Web Agri Stat

Package 2.0 (WASP) and significance of mean difference was determined by Duncan's multiple range test.

Results and Discussions

Physical properties of control and horse gram flour biscuits

There were significant (p<0.05) differences in the weight, diameter and thickness of the biscuit samples (Table 3). The weight of control whole wheat flour biscuit was highest (8.43 g) and decreased significantly (p<0.05) as the level of horse gram flour in the biscuits increased. The result was similar to that of Tiwari *et al.,* (2011) [30] and Inyang *et al.,* (2018) [31] where a significant decrease was observed in the weight of the biscuits with an increase in the proportion of pigeon-pea flour and kidney bean flour respectively. Decrease in weight of biscuits as a result of legume flour substitution may be due to their high water holding capacity (WHC) as they have high protein content (Aziah *et al.,* 2012) [32].

The diameter of the biscuits ranged from 4.98 – 4.65 cm. There was a significant decrease (p<0.05) in the diameter of the biscuit as a result of horse gram flour incorporation. A continuous decrease in the diameter of biscuits with an increase in the level of black gram flour and pigeon-pea flour respectively has also been reported by Patel and Rao (1995) [33] and Silky and Tiwari (2014) [34].

Table 3: Physical properties of biscuits

	Weight	Diameter	Thickness	Spread Ratio
Control	8.43±0.07^{a}	4.98±0.02^{a}	0.79±0.01^{a}	6.28±0.08
T1	8.22±0.02^{b}	4.88±0.04^{ab}	0.78±0.02^{a}	6.29±0.32
T2	8.07±0.03^{bc}	4.83±0.02^{bc}	0.76±0.03^{ab}	6.36±0.15
T3	7.96±0.03^{cd}	4.79±0.05^{bcd}	0.73±0.04^{abc}	6.57±0.20
T4	7.81±0.04^{de}	4.76±0.03^{cd}	0.74±0.02^{abc}	6.47±0.19
T5	7.68±0.08^{ef}	4.71±0.03^{de}	0.71±0.01^{bc}	6.64±0.07
T6	7.63±0.06f	4.65±0.04^{e}	0.68±0.02^{c}	6.85±0.12
CD at 5%	0.156	0.101	0.069	NS

Values are represented as Mean±SE for three replicates.
Different alphabets in superscript in each column shows significant difference between values at 5% level of significance (p<0.05). NS= Non Significant

The thickness of the biscuits decreased significantly (p<0.05) as the inclusion of horse gram flour increased in the biscuit formulation. Similar observation of decrease in the thickness of cookies as a result of soy-flour substitution was found by Ndife *et al.,* (2014) [35]. Silky and Tiwari (2014) [34] and Qayyum *et al.,* (2017) [36] also reported a decrease in the thickness of biscuits with increase in the level of pigeon-pea flour and pea flour respectively.

Spread ratio is used to determine the quality of flour used in preparing biscuits and the ability of the biscuits to rise (Bala *et al.,* 2015) [37]. Thus higher the spread ratio, greater will be the desirability of the biscuits (Chauhan *et al.,* 2016) [38]. A general increase in the spread ratio was observed with the increase in the substitution of horse gram flour in biscuits, however, the increase was not statistically significant (p<0.05). Increase in the spread ratio of biscuits with the increase in legume flour substitution has also been reported in other studies (Silky and Tiwari 2014; Ndife *et al.,* 2014; Qayyum *et al.,* 2017) [34-36].

Sensory evaluation of control and horse gram flour biscuits

Sensory properties of biscuit

The sensory evaluation of a product helps in determining its quality, market potential, batch-to-batch variation if any, and pricing. It also reduces the chances of product failure (Dubey *et al.,* 2020) [39]. The scores for the sensory parameters of the biscuit samples are presented in Table 4. The biscuit samples varied significantly (p<.05) in terms of color, flavour, taste, texture and overall acceptability scores.

Color is an important attribute for consumers, who purchase and consumes any food product, including biscuits, on the basis of their color (Krystyjan *et al.,* 2015) [40]. The color developed during the baking stage can be used to determine the final stage of the baking process. The highest colour score was obtained for the biscuits made from whole wheat flour (8.57) followed by biscuits prepared by substitution of 5 per cent (8.07) and 10 per cent (7.93) horse gram flour respectively. The score for colour was lowest for 30 per cent horse gram flour supplemented biscuits (6.9). The study revealed that colour scores decreased with increasing incorporation of horse gram flour with whole wheat flour. The biscuits with higher proportion of horse gram flour were significantly darker, mainly due to the darker color of the horse gram flour. The dark colour of the legumes and wheat bran from whole wheat flour play a significant role in term of biscuit colour. Also, the composite flour biscuits may be darker in colour due to maillard reactions between reducing sugar and amino acids which forms high-molecular weight macromolecule called melanoidins during baking (Morales and Jimenez-Perez, 2001; Krystyjan *et al.,* 2015) [41, 40].

Table 4: Sensory scores of whole wheat flour biscuits (control) and horse gram flour incorporated biscuits

	Colour	Flavour	Taste	Texture	OA
Control	8.57±0.11^{a}	8.50±0.12^{a}	8.37±0.11^{a}	7.53±0.13^{b}	8.24±0.06^{a}
T1	8.07±0.09^{b}	7.73±0.09^{bc}	7.77±0.12^{bc}	7.20±0.11^{cd}	7.69±0.05^{bc}
T2	7.93±0.12^{bc}	7.87±0.16^{b}	7.43±0.12^{cd}	7.03±0.06^{d}	7.57±0.04^{cd}
T3	7.7±0.09^{cd}	7.43±0.13^{c}	7.53±0.13^{bcd}	7.40±0.12^{bc}	7.52±0.06^{d}
T4	7.5±0.10^{de}	7.50±0.12^{c}	7.23±0.08^{d}	7.70±0.13^{ab}	7.47±0.04^{d}
T5	7.3±0.08^{e}	7.90±0.11^{b}	7.80±0.14^{b}	7.93±0.13^{a}	7.73±0.05^{b}
T6	6.9±0.05^{f}	7.03±0.09^{d}	6.80±0.13^{e}	7.00±0.13^{d}	6.93±0.04^{e}
CD at 5%	0.268	0.335	0.336	0.330	0.143

Values are represented as Mean±SE for fifteen values.
Different alphabets in superscript in each column shows significant difference between values at 5% level of significance (p<0.05)

Highest flavour scores were observed for whole wheat flour (control) biscuits (8.50) followed by 25 per cent horse gram flour incorporated biscuits (7.90) whereas, lowest was for 30 per cent horse gram flour biscuits (7.03). Taste is an important attribute which has a greater influence over the acceptability of any food product. Results of the study revealed that biscuits made from whole wheat flour scored higher in comparison to horse gram flour incorporated biscuits. Further, it was observed that the addition of horse gram flour to the biscuits upto 25 per cent resulted in better taste and the scores decreased with further increase in the level of horse gram flour.

Texture is one of the most desirable characteristic which significantly contributes to the overall quality and acceptability of the food products (Bourne, 1990) [42]. The mean score for texture was highest for biscuit prepared by incorporating 25 per cent horse gram flour (7.93) followed by that made by adding 20 percent horse gram flour (7.70). Whole wheat flour biscuit obtained a score of 7.53 in terms of texture. Baking conditions employed, the type and quantity of ingredients and protein content of the flour generally influences the hardness and other textural attributes of biscuits (Gaines, 1993; Pyler, 1988) [43, 44].

The overall acceptability of a food is influenced by their intrinsic properties that are the appearance, aroma, flavor, texture, aftertaste, and auditory attributes of the food which are judged by sensory analysis (Murray and Baxter, 2003) [45]. Overall acceptability scores were highest for whole wheat flour (control) biscuits (8.24). Among the horse gram flour biscuits, the biscuit with 25 per cent horse gram flour incorporation had highest overall acceptability (7.73) and the acceptability scores subsequently decreased with further increase in the horse gram flour substitution. This may be because the biscuits containing high levels of horse gram flour may have an undesirable aftertaste and lacking the characteristic crispness and texture associated with biscuits. Similar result was obtained by Aleem Zaker *et al.*, (2012) [46] where the overall acceptability scores of the biscuits increased with the increase in the concentration of defatted soy flour upto 20 per cent after which it decreased sharply. The results of the sensory evaluation of biscuits prepared by incorporating horse gram flour were in accordance to the findings of Masur *et al.*, (2009) [47], who reported increasing the levels of bengal gram flour in the biscuits resulted in significant decrease in sensory attributes of the biscuits.

Conclusion

From the study, it was found that the addition of horse gram flour to whole wheat flour significantly (p<0.05) altered their physical characteristics such as the weight, diameter and thickness. However, the spread ratio which is an important desirable characteristic of the biscuits increased insignificantly. Sensorial data revealed that horse gram flour biscuits have a good acceptability upto 25 per cent level of incorporation beyond which it declined. The biscuits prepared with the supplementation of 25 per cent horse gram flour to whole wheat flour were liked most by the panelists. Therefore, from the above discussion, it can be concluded that horse gram flour up to the level of 25 per cent can be successfully incorporated to whole wheat flour to develop biscuits without adversely affecting their overall acceptability. Also, horse gram flour can be a viable alternative for the enrichment of biscuits as well as other oven-baked products and that it could be a suitable substitute for commercial whole wheat flour to develop value added products with better nutritional quality.

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