Original Research Article

Evaluation of physical, chemical and sensory properties of multigrain cookies prepared using wheat, oats and barley flours

Abstract

Barley, oats and wheat flour was used to formulate composite flour (CF). Composite flour (CF) was made by substituting wheat flour with oats and barley in different proportions of blending, that is20%, 40%, 60% and 80%. The physical and functional attributes of different blends of composite flour were studied. The qualitative analysis of the prepared multigrain cookies was examined on the basis of physical and proximate analysis. In composite flour, the content of fat, protein and carbohydrate increased as the mixing proportion of the flours increased steadily. The Water absorption capacity (WAC) and swelling capacity (SC) of the composite flours progressively increased as the proportions of the flours blending increased. Furthermore, the diameter of the cookies also decreases with increasing level of blending proportion in wheat flour, and the same effect can increase the hardness nature of the cookies. The cookies prepared from the 80% blend (CF4) achieved the highest overall acceptability score.

Keywords: composite flour, barley, oats, wheat, cookies

1. Introduction

"Cereal crops are the main food and feed sources worldwide, supplying more than half of the calories consumed by humans" (Loskutov et al. 2019). An overwhelming majority of plant breeders and geneticists work on no other crops but cereals including wheat, oats and barley. Breeding methods depend on the biological features of a crop and on the genetic research standards, traditions, economic objectives, and levels of agricultural technologies in the country where plant breeding is underway.

"Day by day consumption of baked products by human coupled with the escalating cost of wheat importation and difficulty in cultivating wheat in the tropics has focused attention on the need to explore the use of alternative local flours as supplements or substitutes for wheat flour in the baking industry. In this regard several researchers have worked extensively on composite flour for the production of biscuits, buns, cakes and bread. Composite flour refers to the mixture of different concentrations of non-wheat flours from cereals, legumes, roots and tubers or mixture of flours other than wheat flour" as described by Collar and Angioloni, (2014). "In addition; Barley (*Hordeumvulgare* L.), one of the first domesticated crops, is now one of the most important cereals. It is cultivated worldwide in many countries and regions with temperate climates in summer and some regions with temperate and subtropical climates in winter. Barley was probably first used for human consumption" as discussed by Lukinac et al. (2022) Healthy diet adoption is one of the crucial way to eradicate our self from disease causing agents. The increasing awareness about benefits of intake of healthier diets containing natural nutritional constituents has led to the development of a chain of functional food stuffs (Chauhan et al. 2016).Developing the quality functional foods is a challenging task for several food industry due to limited source of plant materials with its nutritive constituents, technology limitation and sensory attributes. Previously most of the bakery and confectionery food items are produce from wheat flour (Diana et al. 2007) could be attributed to its gluten content.

Gluten is a storage protein of cereals crops, as it has vital function in dough and bread manufacturing process (Woodward, 2015) but its presence in wheat flour makes most of the population more sensitive to the several harmful disorders such as wheat allergy, celiac disease, dermatitis herpetiformis, and gluten ataxia.

"Thus gluten free diets are a good solution for gluten sensitive populations which has led to develop such nutritive composite flour from oats and barley. However, novel composite flour enriched with nutritional ingredients like cereals crops, tubers, starches, legumes (Bourre et al. 2019; Kushwaha and Verma 2017; Noorfarahzilah et al. 2014) and multigrain premixes (Kumar, 2015) in which wheat flour is replaced with other cereal grain flour thereby; reduced the risk of diet-related disease and allergies"(Rosell and Matos, 2015). In addition, wheat flours blended with oats and barley cereals used to prepare bread in a bulk scalein order to maintain the proper dough consistency (Badiu et al. 2014; Blessing, 2014).Other than this, other kind of composite flours are also used to manufacture bakery food products such as pasta (Seczyket al. 2016), bread (Ho et al. 2013; Astaet al. 2013) and cookies (Cheng and Bhat, 2016; Zouariet al.2016; Wu et al. 2018).Therefore, cereal based flours have been used to produce various kinds of staple food stuffs worldwide for high nutritive and energy values (Tebben et al. 2018; Xu et al. 2019).

The present study was commenced to investigate the physical and functional properties of composite flour by supplementing wheat flour with oats and barley flour. The composite flour was further employed to make cookies, and assessed the cookies physical and sensory characteristics.

2. Materials and methods

2.1 Raw materials

All the required samples of wheat (Sharbati), oats (Bundel Jai-851) and barley (Dara) grains were purchased from the Meerut local market, India.

All the collected cereal grains were fined through the end milling instrument into flours. Fined flours of wheat, barley and oats were cleaned by passing through the 30 mm mesh sieve filters. Composite flour was prepared by mixing the different combination of barley (BF), oats (OF) and the wheat (WF). Composite flour (CF) of collected cereal grains was used to substitute wheat flour with CF at various proportions *i.e.* 10% (TF1), 20% (TF2), 30% (TF3), 40% (TF4). The prepared composite flours was then packed in air tight container and kept for further studies. While sample treated as control sample where no addition of barley and oats flour in wheat flour.

2.2 Proximate analysis of composite flour of cookies

Protein, fat, moisture, ash and crude fiber were calibrated according to the AOAC, (2000) standard protocol. The carbohydrate content in the sample was evaluated by using the subtraction method *i.e.*(%) carbohydrate= 100-%(protein+fat+fiber+ash+moisture) as described by James, (1995).The energy content of the samples were determined by Nielsen, (2009).

Ash content

The ash content in the sample was estimated according to AOAC (2000).

Five grams of the sample was weighed accurately into pre-weighed porcelain crucible (which has previously been heated to about 600^{o}C and cooled). The crucible was heated in a muffle furnace for 6-8 hrs at 600-700ºC. It was cooled in desiccator and weighed.

To ensure completion of ashing, the crucible was again heated in a muffle furnace for 1-2 hrs, cooled and weighed. This was repeated until the consecutive weights were the same and the ash was almost grayish-white in color.

$$\text{Ash (\%)} = \frac{\text{initial weight of empty crucible} - \text{Final weight of the crucible with ash}}{\text{sample weight}} \times 100$$

Moisture content

The moisture content in the sample was estimated according to the method of AOAC (2000).

The petridish with lid was weighed. 10 g of sample was weighed into the petri dish and spread evenly for uniform drying. The oven was set at 100 to 105°C and the petri dish with the sample was placed inside the oven with the lid open for 15-17 hrs. The petri dish was cooled in a desiccator with the lid open for 1-2 hrs. The petridish with the sample was weighed. Same procedure was repeated for all samples till constant weight was achieved.

$$\text{Moisture (\%)} = \frac{\text{Difference in the weight}}{\text{sample weight}} \times 100$$

Protein estimation

Quantification of the protein was measured using the spectral lab. semi-automatic titration analyzer by following the Kjeldhal method (AOAC, 2000). The percentage of nitrogen present in the sample was estimated to calculate the exact amount of protein present in the sample as per given formula:

$$\text{(\%) } N_2 \times 6.25 \text{ factor}$$

Fat content determination

The crude fat content of the sample was determined by the procedure as described in AOAC (2000).Five grams of a sample was weighed accurately, placed in a thimble and plugged with cotton. The extractor-containing thimble was placed over a pre-weighed extraction flask (A).

Fat content was determined by extracting the sample with solvent petroleum ether (AR grade 60-80°C) for 8h, using Soxhlet extraction procedure. After extraction, the excess of solvent was distilled off and the residual solvent was removed by heating at 80ºC in an oven for 4-6 hrs.

Crude fat content was calibrated as per given formula:

$$\text{Crude fat (\%)} = \frac{\text{Weight of lask B} - \text{Weight of lask A}}{\text{Weight of the sample}} \times 100$$

Fiber content determination

The total crude dietary fiber was determined as per standardized Method (992.16, already prescribed by Association of Official Analytical Chemists (AOAC), 2012).

The flour sample amount of (2g) was taken for weighed measurement into the fiber flask and then adds 100 ml of 0.25N H_2SO_4. The prepared reaction mixture was then heated under reflux condition for 1hour with the use of heating mantle plate. The heated mixture was then refined through a fiber sieve cloth. The obtained filtrate was discarded and the rest residue was pour off into the fiber flask, wherein; 100 ml of (0.31N NaOH) was added and reflux again for another 1h. The same reaction mixture was filtered and 10 ml quantity of acetone was added in order to dissolve any organic constituent. And rest of the residues was washed twice with 50 ml of hot water on the sieve cloth and finally washed residues were transferred into the crucible.

Before transfer to crucible, both crucible and residue were oven-dried at 105°C overnight to drive off extra moisture. The oven dried crucible containing the residue were cooled in a desiccator and later weighed to obtain the weight W_1. The weight W_1residue with crucible was transferred to the muffle furnace to obtain ash at 550 °C for 4 hours. The crucible containing white or grey ash (free of carbonaceous material) was cooled in a desiccator and weighed to obtain W2. The weighted difference (W_1 - W_2) provide overall calculated weight of crude fiber. The percentage crude fiber was calibrated by using the formula (AOAC 1990).

$$\text{Crude iber}(\%) = \frac{(W1 - W2)}{\text{Weight of sample}} \times 100$$

Total carbohydrate content determination

The total carbohydrate content was estimated as per the Anthrone method described by James, (1995). Five gram of sample was extracted with 25 ml of 80% alcohol. The obtained extract was then filtered and placed in a centrifuge at 6000 rpm for 10min. The obtained supernatant was taken for further analysis. About 0.5 ml quantity of the supernatant was taken in a 100 ml volumetric flask and diluted with distilled water up to the desired mark. From each solution, one ml was taken in a test tube, one ml of 5% phenol solution and 5 ml of 98% concentrated H_2SO_4 were added, later the sample was cooled to room temperature by keeping in a water bath at 25 to 30°C for 20 min. The absorbance of the prepared samples was calibrated at 515nm with the3 help of UV-vis-spectrophotometer (model: double beam spectrophotometer-2202; Systronics).

The concentration of carbohydrates in the sample was determined using standard curve.

The carbohydrate content of the sample was estimated by using the following the equation:

$$\text{Carbohydrate (\%)} = \frac{x}{0.1} \times 100$$

2.3 Physical properties of composite flour of cookies

Bulk density was determined by computing the actual dimension of the developed cookies and calculated as the ratio of mass to volume of the cookies and expressed in g cm^{-3} as described by (Chandra et al. 2014). Calibration of bulk density was done with the help of given formula and represented as:

$$\text{Bulk density} = \frac{4 \times m}{\pi \times d2 \times L}$$

Where;

L= Length of the cookies, cm; d= Diameter of the cookies, cm; m=Mass of the cookies, g

Tap and true density of samples were determined according to the Deshpande and Poshadri (2011) method. Porosity was calibrated through the pycnometer (Mohsenin, 1986). This porosity determination was accurately measured according to the formula:

$$\phi = 1-(d/dmax)$$

Where, d= bulk density; and d_{max}= maximum bulk density when all the void space are filled.

2.4 Functional properties of composite flour of cookies

Water absorption (WA) and oil absorption capacity (OAC) are calibrated according to the method of Sosulski, (1976).One gram (1g) of the cereal flour sample was suspended with 10ml of distilled water or refined soybean oil under ambient temperature for 30min and centrifuged reaction mixture for 10min at 2000Xg. Each obtained value was represented as (%) water and oil bound per gram of undertaken sample. Swelling power (SP), solubility capacity (SC) and alkaline water retention capacity of prepared flour sample was calibrated using the AOCC method, (2000).

2.5 Energy content calculation of cookies

The Cookies flour energy content was measured simply by equating and multiplying the number of grams of carbohydrates, protein, and fat by 4 kcal, 4 kcal, and 9 kcal, respectively. Then added each of them to obtain energy content. Hundred gram (100g) of flour was used as sample for calibration purpose. Computation of total energy count was measured by Nielsen, (2009):

$$\text{Energy content} = (\text{carbohydrates} \times 4\ \text{kcal}) + (\text{protein} \times 4\ \text{kcal}) + (\text{fat} \times 9\ \text{kcal}).$$

2.6 Cookies formulation

The cookies were prepared in (%) combination of Wheat: barley: oats in proportion of (80:10:10), (60:20:20), (40:30:30), (20:40:40)and 100:0 (control) of Wheat flour, respectively. Henceforth, since oats and barley contain lesser amount of gluten content, while sugary syrup containing cookies formulation was elected for further study. Additional ingredients are also included in the dough preparation like amount of sugar, shortening, salt, water and other ingredients were added to maintain the quality cookies flour production (AOCC, 2000). Proximate analysis of prepared cookies was determined according to AOCC, (2000). The amount of sugar, fat, baking powder and salt used in every formulation was 47.2, 55.5, 1.9 and 0.55 parts respectively (Ishimoto et al., 2007).

Table 1 Cereal grains combination for the formulation of composite flour

Combinations	Wheat flour	Oat flour	Barley flour
Control	100%	-	-
CF1	80%	10%	10%
CF2	60%	20%	20%
CF3	40%	30%	30%
CF4	20%	40%	40%

Wheat flour=WF; Oats flour= OF; Barley flour= BF and composite flour= CF

Fat and sugar powder was first creamed. Salt was dissolved in water and added to the prepared cream mixture. As the creaming process continued; wheat flour, oats flour, barley flour, and baking powder were added and mixed well together. The flowchart of the overall production of cookies is given in Figure 1.

Preparation of Ingredients (Weighing and Recipe calculation)

⇩

Creaming of sugar and fat (5-8 min)

⇩

Mixing with flour mixture and baking powder

⇩

Dough forming with the addition of water and salt

⇩

Sheeting and shaping (Thickness: 3-4 mm)

⇩

Baking (180-200℃ for 15-20 min)

⇩

Cooling at room temperature (21℃)

⇩

Packaging in a polyethylene bag

Figure 1: Flow chart of preparation of cookies

Following this methodology, proximate analysis and energy value were also evaluated of cookies in the same manner as calibrated for composite flour.

2.7 Physical evaluation of cookies

The calibration of cookies diameter (width), thickness and spread factor was evaluated according to the following AOCC, (2000) method. Spread factor ratio was measured by calibrating the diameter and thickness of cookies using the formula:

Spread ratio: Diameter (D) / Thickness (T) (EQ. 2)

Where, D is the diameter and T is the thickness of cookies. Breaking strength of cookie was evaluated using the HDP/BS blade.

2.7 Sensory evaluation

Sensory evaluation of cookies was done on the basis of overall acceptability of their color, flavor, smell, elasticity, firmness and texture which can be counted as 9-point hedonic scale and it was carried out by ten semi-trained panelists. The panelists were screened initially based on their sensitivity to recognize the basic tastes. A training session was conducted to define the sensory terminologies. The samples were then presented to the panelists in a random order provided with a glass of water for rinsing purposes. The sensory evaluation was done in a welllit and properly ventilated laboratory, and the panelists evaluated each sample for every attribute according to the 9-point hedonic scale. A nine point hedonic scale with 1 point scale is equivalent to completely product rejection, 5 point scale indicate neither like nor dislike and 9-point hedonic scale display extremely agreed to use (Dutcosky, 2011).

2.8 Statistical analysis

Experimental data was analyzed using one-way and two way analysis of variance (ANOVA) trials in a completely randomized design (CRD) with three replications. Stats data was analyzed by using the software SPSS vers. 18. A significant level of 5% was selected to interpret the obtained results after statistical investigation. Critical difference (CD) was calibrated to determine the significance difference between the samples for each parameter.

3 Results and Discussion

3.1 Proximate analysis of wheat and composite flour

Oats and barley flours and wheat flour were comparatively distinguished on the basis of proximate composition at significant $p<0.05$ level. Wheat flour have more than (13.08%) moisture content thereby; WF is more prone to contaminated with microbial growth and insects. The moisture content in different composition of flour blends was found no statistically differences as mentioned in table 2. Similar results were obtained by Iwe et al. (2016) for proximate analysis for rice, brown cowpea seed composite flour. In another study Maskey et al. (2021) prepared composite flour of wheat, barley and oats and observed that that the moisture content of optimized cookies was 2.88% while control was 3.42%, the lower moisture content of optimized may be due to the incorporation of barley malt flour which had quite low moisture content compared to wheat flour. The lower moisture content gives better crispiness to the cookie and also becomes less prone to microbial attack. Moisture content is also affected by type of milling technology used and percent moisture content present in composite and wheat flour.

Parameters	WF	CF1	CF2	CF3	CF4	CD P<0.05 (level)
Moisture (%)	13.08±0.21	12.54±0.12	12.23±0.92	12.14±1.2	12.02±0.22	N/A
Protein (%)	13.20±0.075	13.56±0.125	13.65±0.015	14.05±0.26	14.65±0.325	0.218
Fat (%)	1.80±0.063	2.2±0.07	2.56±0.072	2.69±1.22	2.84±1.06	0.234
Carbohydrate (%)	69.90	69.71	70.54	70.66	71.67	-
Ash (%)	0.75±0.025	0.67±0.015	0.90±0.012	1.04±0.122	1.09±0.047	1.09
Crude fiber (%)	0.62±0.005	1.01±0.012	1.74±0.225	2.07±0.029	2.49±0.25	0.186
Energy value (KJ)	292.8	314.12	329.44	342.167	355.14	-

Table 2. Proximate composition of different composite flour blends

CD= Critical differences; WF= Wheat flour; CF1=(composite flour 10% oats + 10% barley mixing); CF2= (composite flour 20% oats + 20% barley mixing); CF3=(composite flour 30% oats + 30% barley mixing); CF4= (composite flour 40% oats + 40% barley mixing).

The oats and barley composite flour have greater protein content than wheat flour as presented in table 2. It was varied from 13.56% to 14.65% and relatively higher as compared to wheat flour (13.2%). High percentage of total protein content in CF4 composite flour has been increased than control (WF) sample as shown in table 2. As per statistical analysis the percentage of protein content of composite flours were differed significantly than the wheat flour (WF) sample.

Fat content of composite flours was significantly increased over wheat flour (WF), which considered as control sample. Although, fat content of blended flour varied from 2.2% to 2.84%, its increased content is reflected at all the level of blending percentage as it was statistically differed due to CD values differences at $p<0.05$ level.

The (%) carbohydrate content in composite flours was differed than the control. Its content varied gradually from 69.71 to 71.67% due to increased percentage of blending of oats and barley flours than wheat flours as displayed in table 2. With the increment in blending proportion of composite flours (20:40:40), the ash content of the flour was elevated as compared to wheat flour. The composite flour ash content was significantly differed from 0.67-1.09% as it was concluded from these results that CF4 composite flour has greater purity index over (WF) control sample. Higher purity index indicate increment in blending proportion of composite flours which means enhancement in flour quality as compared to wheat flour.

In addition, the fiber content of blended flours assessed and its content varied from 1.01 to 2.49%indicating that fiber content was increased with increment in CF4 blending proportion over control sample. Similar kind of findings had described by Alka et al. (2017), both barley and oats crude fiber were found significantly higher than control flour. High fiber content containing composite flour (CF4) intake eradicate the problem of bowel syndrome and colon cancer. Same high fiber content consumption also reduced the risk of Type-2 diabetic disorder as quoted by Alka et al. (2017).

As per obtained results shown in table 2 shows that energy value (KJ) increased with the increment in percentage of composite flour than wheat flour content. The basic reason behind of energy value increment was due to increment in protein and fat amount as blending proportion of composite flour is increased.

3.2 Physical characteristics of composite flours

As more and more composite flour was added into the wheat flour, the bulk density of developed flours was decreased. The bulk density varied from 0.41gm/l (CF4) to 0.49gm/l (CF1) as compared to wheat sample as mentioned in table 3. Gradual decrement in bulk density was observed as the reduction in the size of particles and density of the flour. Bulk density is an important factor in determining the packaging requirement, material handling and application in wet processing in the food industry. Same decrement pattern of composite flours noted in case of tap density (gm/l) as the amount of other cereals crops in wheat flour is increased. It define the fitness of the composite flour.

Parameters	WF	CF1	CF2	CF3	CF4	CD (p<0.05 level)
Bulk density (gm/l)	0.52±0.11	0.49±0.02	0.48±0.05	0.45±0.17	0.41±0.26	N/A
Tap density (gm/l)	0.74±0.26	0.71±0.11	0.70±0.07	0.69±0.31	0.67±0.08	N/A
True density (gm/l)	0.75±0.16	0.73±0.18	0.69±0.24	0.68±0.30	0.65±0.42	N/A
Porosity (%)	30.95±0.12	33.28±1.02	30.5±0.27	32.85±1.45	33.95±1.51	1.93

Table 3. Physical properties of composite flours blends

CD= Critical differences; WF= Wheat flour; CF1= (composite flour 10% oats + 10% barley mixing); CF2= (composite flour 20% oats + 20% barley mixing); CF3=(composite flour 30% oats + 30% barley mixing); CF4= (composite flour 40% oats + 40% barley mixing)

Calibrated true density of wheat flour had maximum value of (0.75gm/l) as compared to other composite flours. It was observed in (table 3) that there was gradual decrement in the true density of composite flours (CF) and this least decrement (0.65gm/l) was noted in (CF4) flour. This gradual decrement in true density reading of composite flour was found highest in CF4 blend because of higher percentage of addition of oats and barley flours as compared to wheat flour. Thereby, the flour densities of oats and barley had lower values as compared to wheat flour as presented in table 3.

Lastly porosity values in composite flour varied from 33.28±1.02 to 33.95±1.51, where CF4 combination had found higher porosity value than wheat flour sample. Higher porosity value indicated that there was animprovementinthe structure of the product, volume, level of digestibilityas discussed by Petrusha et al. (2017).As per the statistically analyzed data of table 3, which determined that there was significant difference between the formulated blends and wheat flour at (p<0.05 level).

3.3 Functional properties of composite flours

Functional properties of different blends of flours were studied and each important properties were shown in table 4. For the table 4, it was concluded that the water absorption ability of flours was increased as the blending proportion is increased. At 20% blend; WAC was 0.66 (ml/gm) which raised up to 0.97ml/gm at 80% blending in wheat flour. These obtained values of WAC were found greater than the values of 2.20g/g and 4.81g/g as reported by Tenagashaw, (2015) who reported that the food stuffs developed by the combination of flour fortified with soyabean and orange flesh sweat potato. Increment of water absorption characteristics in 80% blended composite flour is due to the disruption and dilution of gluten matrix by incorporation of fibers in flours which increased the dough water absorption capacity. Fiber inclusion in composite flour facilitates the hydrogen bond formation and interchange of disulphide bonding between the non-gluten proteins which ultimately breaks the starch-protein complex and promotes the swelling behavior of blended flours as explained by Blessing et al. (2014).

Parameters	WF	CF1	CF2	CF3	CF4	CD (P<0.05 level)
WAC(ml/gm)	0.66±0.12	0.7±0.06	0.77±0.04	0.90±0.12	0.97±0.07	N/A
OAC(ml/gm)	1.10±0.14	0.92±0.17	0.98±0.14	1.09±0.56	1.08±0.55	N/A
SP (%)	6.25±1.2	8.41±0.08	9.06±0.17	9.41±0.09	9.47±1.06	1.418
SC (%)	15.45±1.54	6.94±1.06	9.67±0.08	10.56±0.13	10.96±1.22	3.67
AWRC (%)	56.66±0.33	57.63±1.71	57.87±1.29	58.33±1.53	58.67±1.66	0.534

Table 4. Functional properties of composite flours blends

WAC= Water Absorption Capacity, OAC= Oil Absorption Capacity, SP= Swelling Power, SC= solubility capacity, AWRC= alkaline water retention capacity

From table 4 and fig 2 presents the oil absorption capacity (OAC) of blended flours that was lesser than the wheat flour.

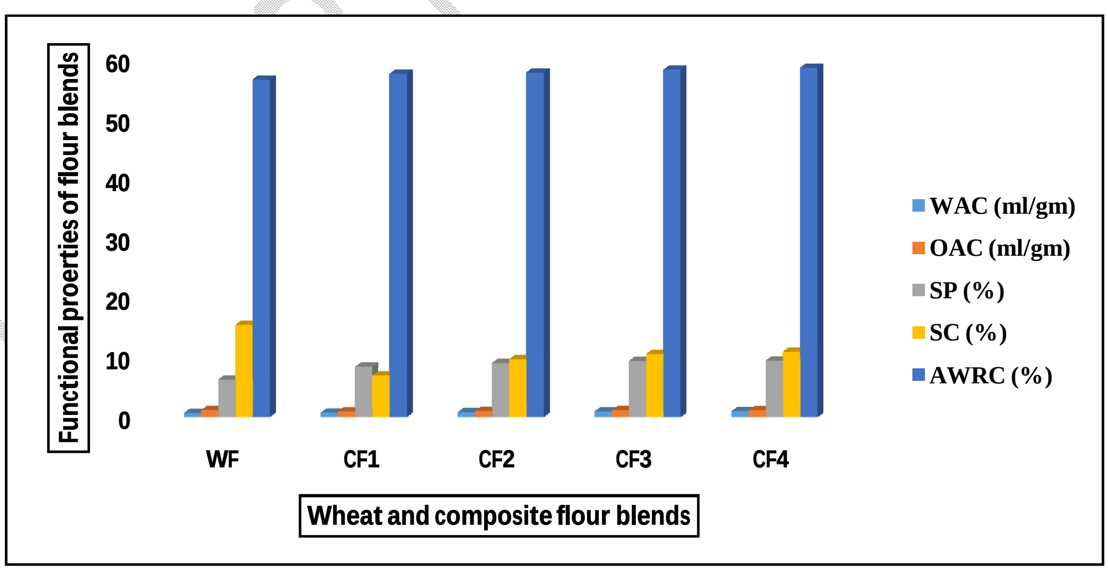

Figure 2. Functional properties of composite flours blends

OAC value varied from 0.92 (ml/gm) to 1.10 (ml/gm) as the blending proportion of oats and barley flours in wheat flour is increased. Chandra et al. (2013) reported that gluten protein presence in flour raised the ability of protein to bind with oil, thereby; OAC was found higher in wheat flour as compared to other blended flours. Another functional parameter of blended composite flour is swelling power (%) which gradually show increment in swelling behavior in composite flour as compared to wheat flour. Its values consistently showed increment from 8.41(%) to 9.47(%) upon increment in blending proportion of flours in wheat flour.

However, solubility capacity parameter reflect the soluble starch content in flour and it was observed in this study that the solubility capacity index gradually increased with the increment in the blending ratio of oats and barley in wheat flour as water interacted with the flour. Similar kind of observations was reported by Iwe et al. (2016). In addition, higher (AWRC) index value reflect the greater cookies diameter.

All the formulated flours significantly showed higher AWRC 58.67% (CF4 at 80% increment in blending proportion) than the wheat flour as already discussed previously by Ajatta et al. 2016 for composite flours development from wheat.

3.4 Preparation of multigrain containing cookies

The prepared cookies from different blends of flours other than wheat flour has lower moisture content, which reflects the lesser chance of contamination with microbial gents and it has better storage stability as well. As per presented data in table 6, which showed the increment in the blending proportion of different flours for cookies preparation, reflected the alteration in the moisture content from average value 2.41% of the CF1to 2.23% of the CF4flour cookie. This increment in the moisture content could be augment the water binding capability of composite flour. Thus the water binding capacity of all composite flour was found to be higher over wheat flour. The moisture content (%) of the cookies ranged between 3.34 and 4.06. The moisture content of the cookies was low enough (<10%) to reduce the chances of spoilage by micro-organisms and consequently guarantee good storage stability (Ayo et al., 2007).Gernah et al. (2010) reported higher moisture content (5.20–9.30%) for cookies made from wheat-brewers spent grain flour blends.

The blend proportion and its interaction with water were observed to have a significant effect on the protein content. It was observed the protein content of the composite-wheat blend for cookies preparation was lied in the ranged from 6.49 to 6.98%. The studied results were found in line with the Ojinnaka*et al*., (2009) who reported the cookies made from taro-wheat blend has more nutritious values as compared to wheat flour made cookies.

The fat content of the cookies was found to be significantly affected (at $p<0.05$) with blend proportion and their interaction. Increment in the amount of fat in the cookies confirmed with the blending proportion increment of composite flours in wheat flour. This is may be due to the presence of higher fat content in the oat and barley flour than wheat flour.

The finding agrees with Omeire and Ohambele (2010) and Gernah et al. (2010) on their reports for the increasing trend in the fat content of the cookies produced from wheat-defatted cashew nut and wheat-brewers spent grain (2.52–4.80%) flour blends respectively. The presence of high fat content in the cookies means high calorific value and also serves as a lubricating agent that improves the quality of the product, in terms of flavour and texture. In addition, fat is a rich source of energy and is essential as carriers of fat soluble vitamins; A, D, E and K. However, high levels of fat in food products should be ≤25%, since this could lead to rancidity in foods and development of unpleasant and odorous compounds (Ihekoronye&Ngoddy, 1985).

Along with this, substitution of wheat flour with composite flour, could raise the ash content in cookies. The ash content increment may be due to presence of high mineral content in the composite flour than wheat flour and selected composite flour can used to make cookies. Since composite flour having barley and oats flour was observed to have significant amount of ash content over wheat flour, this could be responsible for the higher ash contents of cookies with higher proportion of composite flour. In composite flour blend cookies, the fiber content varied from 0.86 to 1.70%. The average values of crude fiber content of the cookies showed significant increment with an increase in blending proportion of composite flour.

Ash is the inorganic residue remaining after the removal of water and organic matter by heating in the presence of oxidizing agent (Sanni, et al., 2008). It aids the metabolism of other compounds such as fat, protein and carbohydrate (Okaka&Ene, 2005). The high ash content indicates high levels of minerals in the composite cookie samples. This suggests that cookies from the composite flour blends will provide more minerals to the consumers than the reference sample. Omeire and Ohambele (2010) observed a similar trend of increasing ash content (1.65–2.20%) in cookies produced from wheat-defatted cashew nut flours. Gernah et al. (2010) also reported similar findings that cookies produced from wheat-brewers spent grain flour blends had high ash content (1.85–2.89%).

The studied results were found consistent with the reported by Ikumola*et al*. (2017) who showed that the blending of citrus by-products flour with wheat flour could raise crude fiber content. Bolarinwa, et al. (2019) also reported that the increment of crude fiber content (from 0.46% to 1.09%) in the sesame fortified cookies. In addition, all the formulated blend flours showed higher carbohydrate contents, which gave cookies more chances to acceptability. This exceptional level of carbohydrate content is due to the presence of ingredients such as wheat, oat and barley flour with high content of carbohydrates. The obtained result was found to be similar with the Ojinnakaet al.(2009) study.

The energy values varied from 928 to 1043 KJ/100gof the composite-wheat flour cookies. Thisenergy values increment is may be due to increment in the proportion of composite flour as compared to wheat flour. The possible reason behind this increment may be due to the fact that with an increase in the composite flour proportion, the fat and protein content would also increase but it show slight decrement in carbohydrate content as shown in Table 5.

Parameters	WF cookies	Composite formulation of flours for cookies				CD (P<0.05)
		CF1	**CF2**	**CF3**	**CF4**	
Moisture (%)	2.39±0.09	2.41±0.22	2.23±0.15	2.98±0.12	2.23±0.12	0.201
Protein (%)	6.36±0.021	6.49±0.25	6.20±0.21	6.08±0.18	6.98±0.31	0.458
Fat (%)	20.75±0.30	20.89±0.19	21.70±0.37	23.67±0.27	23.97±0.53	0.701
Ash (%)	0.91±0.14	0.91±0.40	0.95±0.05	1.05±0.04	1.09±0.13	N/A
Crude fiber (%)	0.66±0.06	0.86±0.49	0.96±0.10	1.55±0.15	1.70±0.20	0.333
Carbohydrate (%)	69.11	68.64	68.11	64.39	63.51	N/A
Energy value (KJ/100g)	925.553	928.738	936.798	1022.7832	1043.056	N/A

Table 5. Proximate evaluation of composite flours blends made cookies

CD= Critical differences; WF= Wheat flour; CF1=(composite flour 10% oats + 10% barley mixing); CF2= (composite flour 20% oats + 20% barley mixing); CF3=(composite flour 30% oats + 30% barley mixing); CF4= (composite flour 40% oats + 40% barley mixing)

3.5 Physical evaluation of developed cookies

Physical evaluation of the multigrain cookies and wheat cookies were shown in table 6. Comparative analysis of multigrain flours with wheat flour was done on the basis of physical parameters and decides the quality of developed cookies.

Parameters	WF cookies	Composite formulation of flours for cookies				CD (P<0.05 level)
		CF1	**CF2**	**CF3**	**CF4**	
Diameter (cm)	3.9±0.20	3.86±0.17	3.80±0.24	3.72±0.12	3.26±0.06	N/A
Thickness (cm)	1.14±0.18	1.33±0.12	1.27±0.14	1.18±0.19	1.15±0.14	N/A
Spread factor	3.55±0.29	2.9±0.22	2.95±0.18	3.15±0.22	3.17±0.18	N/A
Spread ratio	35.5±0.48	29.05±0.34	29.92±0.26	31.5±0.21	31.65±0.34	0.588
Hardness (N)	31.66±1.29	33.66±0.91	32.94±1.77	46.80±1.23	47.66±1.61	2.356

Table 6. Physical evaluation of composite flours blends

CD= Critical differences; WF= Wheat flour; CF1=(composite flour 10% oats + 10% barley mixing); CF2= (composite flour 20% oats + 20% barley mixing); CF3=(composite flour 30% oats + 30% barley mixing); CF4= (composite flour 40% oats + 40% barley mixing)

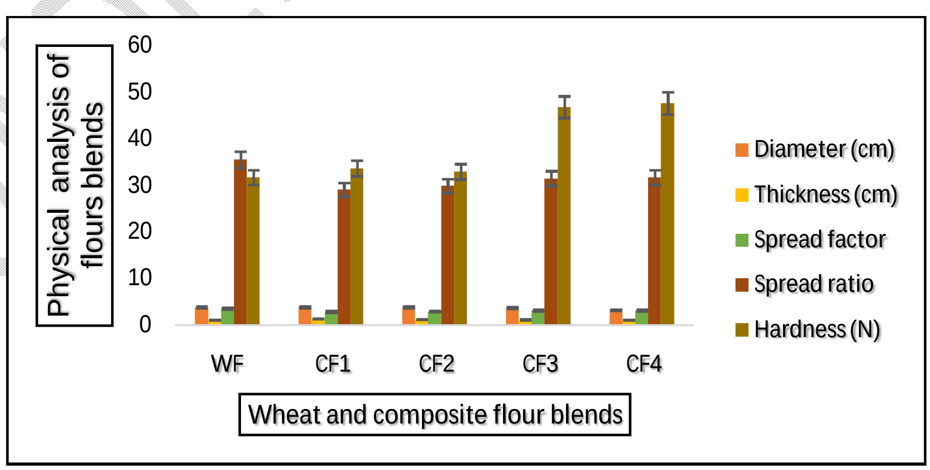

Figure 3. Physical analysis of developed composite flours and wheat flour

Above table 6 and fig 3 showed the diameter of the prepared cookies developed from flours decreased with increasing degree of flour blending proportion. The obtained results were found in the same lines as reported by (Oluwatoyin, 2016).As per obtained statistical data, it was observed that there was no significant difference was found among the diameter of developed cookies prepared by mixing flours in a different ratio in wheat flour. Additionally, the increment of blending flour proportion ratio in wheat flour is also raised the spread ratio consistently.

The study results (table.6) showed that hardness of the developed cookies is increased with increment in the level of supplementation. Control cookies show hardness value (31.66N), whereas its value show gradual increment from 33.66N to 47.66 N when the degree of flour blending is increased from 20% to 80% in wheat flour. The obtained results were found similar to earlier reported results concerning with cookies prepared from wheat-cowpea (McWatters*et al*., 2003) and wheat–soybean (Shrestha and Noomhorm, 2002) flour blends. Along with this fewer studies (Chauhan, et al. 2016) pointed out that the mechanisms related to the cookies diameter compression (*i.e.* spread) is significantly decreased as the wheat flour is added with other cereal flours. However, it has been suggested that spread ratio is also affected by the interaction of ingredients such as protein and starch for the available water during dough preparation (Nirmala*et al.* 2011).

In terms of sensory evaluation of developed cookies all the respective flour formulations were acceptable by consumers and judges andC4 (80% blend) was preferred sample over other samples because it impart the desired sensory characteristics to the cookies.

Sensory Parameters of cookies (CF4)	Results
Elasticity (%)	56.78 ± 0.12
Firmness (g)	718.06 ± 44.34
Flavor	8.17 ± 0.71
Texture	7.92 ± 0.79
Color	8.17 ± 0.81
Smell	8.00 ± 0.81
Acceptability (%)	89.65 ± 5.76
Cookies buy intention	3.90 ± 0.59

Table 7. Sensory evaluation of cookies developed from CF4 blended flour

CF4= (composite flour 40% oats + 40% barley mixing)

Table 7 presents the results of the Chauhan, sensory evaluation performed on the basis of appearance, aroma, texture, color and flavor as well a

s customers purchase satisfaction of the developed cookies produced from different blends of composite flours of oats and barley. Additionally other sensory attributes such as elasticity and firmness of the product predict the texture of the product (Kasunmala et al. 2020).

However, sensory evaluation of CF4 flour blend source from oats and barley was found acceptable and registered overall acceptability index of the cookies was 89.65%, which indicates a possibility of developing cookies with oats and barley flours; moreover, the value of purchase intention was assessed as 3.9, which is closest to a score of 4.0 that shows would buy frequently; this confirms the probability of using oats and barley flour in the development of gluten-free cookies.

4. Conclusion

The nutritional value of all the developed composite flour from oats and barley was found significantly higher than wheat flour. The increment in energy content is also registered with increase in percentage of composite flour in wheat flour. In terms of physical properties, it was observed that wheat flour had high true density (TD) whereas the true density of composite flour was declining due to the increment in the blending in wheat flour. Other than this, it was noted that oil absorption capacity of blended flour was lesser than the control. AWRC increment was found maximal in 80% blend compared to 20% blend. The lightness of flour diminished with cumulative percentage increment of composite flour from oats and barley.

Multigrain cookies thickness is affected by increasing the blending flours in wheat flour. Conversely, hardness of the prepared cookies increased with addition of blend flours, but it reduced the brightness of cookies. (80%) blend (CF4) is a preferred choice of the judges for cookies preparation as it contributed desirable appearance, color, texture, smell and flavor which makes them distinguished it from other flour samples, despite of this, all other samples were also acceptable. Thereby; 80% blended flour sample is suitable choice and it acquired the maximum score for overall acceptability for cookies production. Thus the replacement of wheat flour with composite flours will be profitable business in this sense, as it results into low cost cookies generation**.**

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