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Development of Value Added Products from Byproducts of Ethiopian Wheat Milling Industries

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Abstract

The main of byproducts wheat milling industries, wheat germ and bran have been recognized as an outstanding sources of protein, dietary fiber, trace minerals, antioxidants, phytonutrients' and allied micronutrients. Thus, this research was aimed to develop value added products from wheat germ and bran. Defatted wheat germ flour (DWGF) obtained by supper critical fluid extractor process used as supplement for wheat flour at 10%, 15% and 20% Blend ratio and baking temperatures of 150, 180 and 210°C to produce cookie; whereas wheat bran prior to milling, screening and heating used to make tea substitute. Chemical composition of raw materials, physico-chemical and rheological characterization of flours and value added products were investigated. It was found that protein, fiber, ash and minerals (Ca, K, P and Mg) concentrations in the blends increased significantly ($P<0.05$) with an increase in DWGF substitution. Higher total phenolic content ranged from 1.04 to 3.68 mg of gallic acid equivalent (GAE)/g of dried extract obtained at 60°C using methanol. While antioxidant activity of 60°C extract resulted with lower half maximal inhibitory concentration (IC_{50}) (mg/ml) value of 1.40, 1.75 and 2.13 scavenging activity for ascorbic acid, methanol solvent extract of wheat bran and by absolute methanol; respectively. Furthermore, wheat bran extracted using solvent methanol at 60°C showed potential antioxidant activity and total phenolic content. The Farinograph analyses revealed an acceptable range of dough characteristics up to 15% blend ratio. The cookies baked at 180°C with 15% defatted wheat germ flour and 85% wheat result better nutritional and sensory acceptability.

Keywords: Antioxidant activity; Blending ratio; Byproducts; Cookies; Defatted wheat germ; Supercritical fluid extraction; Wheat milling industries; Value added products

Introduction

Cereal processing industry may be described as any industry that takes a cereal or a cereal product as its raw material. The wheat based industry is a multi-billion dollar market; hence wheat is one of the top three cereals crop in the world. The milling process of wheat produces large amount of wheat bran and germ as a byproduct. During milling, the endosperm is broken down into fine particles (white flour) while bran and germ are removed. Wheat is a significant agricultural and dietary commodity worldwide with known antioxidant properties concentrated mostly in the bran. Wheat germ, being a byproduct of the flour milling industry, is considered a natural source of highly concentrated nutrients at a relative low cost [1,2].

Wheat milling industries release byproducts utilized for animal feed, bio-ethanol production, succinic acid production, like a blend for baked products as nutritional improvement, for cosmetics, meat substitute, neutraceutical/ pharmaceutical products and for many more others. Hence a value addition is any step in the production process that improves the product for the customer and results in a higher net worth of the last product, these byproducts could be used for value addition purpose. Using byproducts from wheat milling industries for value addition is accustomed in the developed countries like U.S.A for instance defatted wheat germ helps meet today's demands for full flavor grain-based foods that are rich in protein and fiber [3].

Wheat germ is the most vitamin and mineral rich part of the wheat kernel. In fact, the germ is actually the embryo of the wheat plant. This embryo will eventually nourish the new wheat plant this is the reason why it has so many wonderful nutrients [4]. Wheat germ oil is used in products such as foods, biological insect control agents, pharmaceuticals and cosmetic formulations [5]. Oil inside the wheat germ extracted using different mechanisms such as the common method organic solvent extraction (Hexane, Methanol, Chloroform-methanol, etc) which recovers about 90% of the oil, by mechanical pressing, which recovers about 50% [6] or by using super critical extraction methods (85%). The extracted wheat germ oil from the former two mechanisms resulted in having lower free fatty acid and α-tocopherol content; in other word oil obtained by supper critical extraction can overcome these negative factors; in fact, the oils are solvent-free and do not need the traditional refining processes, and extraction yields are similar to those usually need to be refined [7].

Above all, recent research demonstrates that wheat grain contains significant level of natural antioxidants, mostly concentrated at the outer part. Wheat is an important agricultural commodity and a primary food ingredient worldwide and contains considerable beneficial nutritional components. Wheat and wheat-based food ingredients rich in natural antioxidants can ideally serve as the basis for development of functional foods designed to improve the health of millions of consumers [8].

Tea/coffee substitutes are non-coffee products, usually without caffeine, that are used to imitate coffee. This substitutes can be used for younger children, medical, economic and religious reason, or simply because coffee is not readily available. Coffee and tea substitutes made from wheat and barley have been produced for a century; however, limited research has gone into the antioxidant benefits from roasted wheat and coffee beverages. As the benefits of wheat antioxidants

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become better known, the wheat and coffee beverage markets may emerge as well. According to researches by naturopathic clinic caffeine stimulates central and sympathetic nervous systems, resulting in an elevation of the stress hormones released by pituitary, adrenal and hypothalamus glands. These hormones can cause short term spikes in our blood pressure by raising both systolic and diastolic pressures. Release of stress hormones causes our body to enter a state similar to a fight or flight response, causing blood to be redirected from our stomach and digestive system and potentially causing indigestion [3].

The aim of this research was therefore to utilize byproducts from wheat milling industries for development of value added products. The products were cookies from blends of defatted wheat germ flour and wheat flour and that of the tea substitute using wheat bran. Analyses were executed for chemical composition of raw materials, mineral concentration of flours and composite cookies developed, rheological and functional properties of flours. Furthermore, antioxidant property (free radical scavenging activity) and total phenolic content of wheat bran in addition to sensory attributes of cookies and tea substitute were similarly evaluated.

Material and Methods

Raw material collection, transportation and storage

The basic raw material used to make a defatted wheat germ cookies and tea substitute were collected from Hora Food Complex found in Alemgena, Ethiopia. Wheat bran, wheat flour (76% extracted) and wheat germ samples were obtained separately during production period. Each flour samples taken carefully from appropriate pipes and kept inside hygienic food grade polypropylene plastic bags at room temperature zipped. Icebox was used during transportation of the wheat germ and bran stored at 2°C till laboratory analyses completed.

Tea substitute preparation

Wheat bran collected were cleaned, dried and milled to a fine powder using an ordinary grinder. Prior to consumption the grounded bran heated at medium temperature till color changed to light brown. Tea bags were used to pack 2.8 g of both with and without essence to give extra flavor like cinnamon, funnel seed and mint [10].

Preparation of defatted wheat germ flour, blends and cookies

The raw wheat germ heated to stabilize enzymes at 105°C for 30 minutes according to the method described by [2]. Then after, defatted using supper critical fluid extractor at 300 bar and 40°C for 250 minutes. Then milled using hammer mill, and passed through 60-mesh sieve diameter. Blend formulation of wheat flour and defatted wheat germ flour at (0%, 10%, 15% & 20%) were done by taking into consideration some important facts about the characteristics of DWGF results obtained after making farinograph analysis [9] and that reported maximum level of substitution could reach till 25%.

Cookies production

Dough for the cookies were prepared using about 110 g of flour blend, 29 g shortening, 34 g of sugar, 13 g of beaten whole egg, and 1.1 g of baking powder, 1.5 g of salt, 1.2 g vanilla, 2 g cinnamon, 1 g clove, 0.6 g ginger and 5.3 g water. First, dry ingredients were weighed and mixed thoroughly in a bowl by hand for 4 min. The shortening, sugar and egg creamed together was added to the mixed dry ingredients and rubbed in until uniform. The dough was sheeted using Lasagna sheeting machine with a uniform thickness (5 mm) and cut out using a round cutter of diameter 45 mm. The cut out dough pieces were baked on lightly greased pans at baking temperatures 150, 180 and 210°C for 11 minutes in a baking oven [10].

Experimental methods of analyses

Proximate composition, minerals and rheological properties of flours: Proximate chemical composition analysis for moisture content, total ash, crude protein, crude fat, and crude fiber of raw materials and finished products were carried out according to [11]. Factors for conversion of nitrogen to crude protein n=5.70 (for wheat flour), n=6.31(for bran) and n=6.25 (for cookies) were used according to [12]. Total carbohydrate calculated by difference excluding crude fiber. Minerals calcium, magnesium and Potassium were determined using [13]. Phosphorus was determined using [14]. A farinograph (physical dough-testing machine) was used to measure the rheological properties of flour for selecting the suitable amount of defatted wheat germ flour as a substitute for wheat flour. The rheological property was measured according to [15] by the Brabender Farinograph equipment and results were obtained as graphic output (Farinogram). The method of [16] was used for measuring the physical properties weight, diameter height and spread ratio of the value added cookies. And averages of the duplicate measures of both blend ratio and baking temperature effect were analyzed.

Functional properties of flours: Functional properties of flours incorporated water absorption, oil absorption and bulk density. Water and oil absorption capacity of flours were determined with the method reported by [16]. Bulk density of the composite flour was analyzed according to the method stated by [17].

Physical properties of cookies: The physical properties of cookies included diameter (width), thickness (height) and spread ratio (diameter to height ratio). Determination of diameter, thickness and spread factor were performed according to the method described by [18] using AACC methods.

Antioxidant activity and total phenolics sample extraction

The extraction process was performed by the method described [19] for extraction. Absolute and solvent methanol used for traditional extraction. About ten grams of grounded fine bran weighed using an aluminum foil and transferred in to a beaker. 40 ml of solvents were added in a beaker. The beakers were capped, placed in water bath at (40, 60 and 80°C) for 20 min and were shaken twice, while it's inside the water bath. For the reason high amount of total phenolic content and better antioxidant activity found when shaker used [20], incubator shaker at room temperature used for further extraction then the solvent layer from each test tube was separated by centrifugation at 2000 rpms for 15 min. The solvent supernatant was transferred to clean, previously weighed test tubes while the residue was extracted with two additional 20 ml portions of solvent as described above; then passed through what man No. 4 paper. The combined extracts were put at 40°C in thermostat oven and weight differences were calculated for each sample. Finally, samples re-dissolved by their respective solvents and placed in refrigerator prior to testing.

Total phenolic content

Phenolic compounds concentration of methanolic extracts was estimated by using slightly modified procedure by [21] as illustrated below. After extraction of the bioactive chemicals, a stock solution of 10 mg/ml extract in methanol (10:1) prepared. Then 1 ml stock solution taken and diluted by 1ml methanol to have 2 ml total volume, but the concentration is diluted by half i.e. 5 mg/ml. 1ml of Folin-Ciocalteu

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and 1ml of 7% of sodium carborbonate added. The samples were vortexed for 3 min before sodium carbonate added. Finally, 7 ml water added to the sample then vortexed for the last time before absorption read. Incubated for 90 minutes and spectrophotometer read at an absorbance of 725 nm model (Perkin Elmer Lamda 950 UV/Vis/NIR). First Gallic acid calibration curve standard is required, so absorption for the gallic acid done in place of extract till $R^2 \geq 0.98$ achieved. All phenolic compounds carried out in triplicate. Total phenolic content was expressed as mg of gallic acid equivalents (GAE)/g weight. The total content of phenolics in wheat bran extracts in gallic acid equivalent was calculated by the following formula:

$$TPC = \frac{(C \times V)}{m} \quad (1)$$

Where TPC is the total content of phenolic compounds, mg/g fresh material, in GAE; C is the concentration of gallic acid established from the calibration curve (Absorbance=0.0134 gallic acid/g–0.0144, R^2=0.9918); V the volume of extract (L); m is the weight of extract the concentration of gallic acid established from the calibration curve.

Free radical scavenging activity

The effect of methanolic extracts on the DPPH radical was anticipated according to [22]. A 0.004% solution of DPPH radical solution in methanol was prepared and then 4 ml of this solution was mixed with 1 ml of various concentrations (2-14 mg/ml) of the extracts in methanol. Finally, the samples were incubated for 30 min in the dark at room temperature. Scavenging capacity was read spectrophotometrically model (Perkin Elmer Lamda 950 UV/Vis/NIR) by monitoring the decrease in absorbance at 517 nm. The maximum absorption was first verified by scanning freshly prepared DPPH from 200 to 800 nm using the scan mode of the spectrophotometer. Ascorbic acid was used as a standard and mixture without extract was used as the control. Inhibition of free radical DPPH in percent (I%) was then calculated:

$$I(\%) = \frac{(A_0 - A_1) \times 100\ \%}{A_0} \quad (2)$$

Where A_0 is the absorbance of the control and A_1 is the absorbance of the sample.

Sensory quality evaluation of value added products

The sensory quality evaluation for coded samples (cookies and tea substitutes) done by using descriptive sensory analysis via twenty five trained panelists using 9-point hedonic scale; with 1=dislike extremely, 5=neither like nor dislike, 9=like extremely was used for attributes according to [23]. It was conducted in Addis Ababa University, Food Process Engineering laboratory in moderately daylight, room temperature. Samples were evaluated for a number of attributes (appearance, taste, flavor, color, texture, aroma and overall acceptability). Then coded samples of cookies and tea substitute were presented to panelists together with water for mouth wash within each taste interval. During selection of panelist factors like health status, personality, smoker and sensitivity were considered.

Experimental design and statistical data analysis

The data obtained from each experiment were analyzed using JMP IN software version 7.0 (SAS Institute, Inc., Cary, NC); using complete randomized design (CRD). Mean separation was performed by "Each Pair Student's t test" for multiple comparisons of means and the statistical significance was defined as P<0.05. For defatted wheat germ enriched biscuits a factor of two; Temperature and blend ratio at level of three attained; while total phenolic content and antioxidant activity of wheat bran data interpreted using Excel, 2007.

Results and Discussion

Proximate chemical composition and mineral content of flours

The results of proximate and mineral analysis of raw materials WF (wheat flour), WGF (wheat germ flour), DWGF (wheat germ flour), and WB (wheat bran) flour used for making cookies and preparation of a tea substitute respectively are presented in Table 1. From Table 1 proximate evaluation of the three flours, DWGF has ash (4.72%), crude fiber (5.18%) and crude protein (28.12%) has a huge difference from WGF with ash (3.9%), crude fiber (1.19%) and crude protein (18.41%) and WF with ash (0.84%), crude fiber (0.45%) and crude protein (9.33%); showed a significant difference (P<0.05). Resulting WF has the lower nutritional content; likewise DWGF resulted having considerable amount of minerals than that of WF. Thus from Table 1 the total amount of minerals and proximate composition obtained from DWGF is much higher than that of WF; thus DWGF can be used for supplementation as substitute of WF for upgrading nutritional content.

Rheological properties of flours

Rheological properties of blended and control flours were analyzed

Proximate Composition		**Flour Types**			
	WF	**WGF**	**DWGF**	**WB**	
Ash (%)	0.84 ± 0.06^{c}	3.90 ± 0.11^{b}	4.72 ± 0.05^{a}	4.8 ± 0.18 ^{a}	
Moisture (%)	11.92 ± .0.06^{c}	12.08 ± 0.04^{b}	12.99 ± 0.07^{a}	10.38 ± 0.06^{d}	
Crude Fat (%)	0.52 ± 0.03^{b}	9.91 ± 0.01^{a}	1.01 ± 0.04^{b}	3.25 ± 0.13^{b}	
Crude Fiber (%)	0.45 ± 0.07^{c}	1.19 ± 0.03^{b}	5.18 ± 0.08^{a}	11.91 ± 0.85^{a}	
Crude Protein (%)	9.33 ± 0.26^{d}	18.41 ± 0.04^{b}	28.12 ± 0.32^{a}	14.17 ± 0.28^{c}	
Total Carbohydrates (%)	77.39 ± 0.17^{a}	54.51 ± 0.18^{c}	53.17 ± 0.19^{c}	67.43 ± .1.80^{b}	
Samples		**Minerals (mg/100 gm)**			
	Mg	**P**	**Ca**		**K**
WF	35 ± 0.14^{b}	192.35 ± 0.64^{b}	27 ± 0.42^{b}		171 ± 0.28^{b}
DWGF	45.95 ± 0.35^{a}	392 ± 0.42^{a}	46.6 ± 0.92^{a}		1044.9 ± 0.14^{a}

All $^{a-d}$ values are means of duplicate ± SD on dry weight basis Means followed by different superscript within the same row differ significantly (P < 0.05).
Where WF=wheat flour, WGF=wheat germ flour, DWGF=defatted wheat germ and WB=wheat bran flour.

Table 1: Proximate composition of wheat flour, wheat germ flour and defatted wheat germ flour.

at constant temperature of 30°C. The rheological measures of a product in the manufacture stage can be useful in quality control [24]. From the farinographs obtained for each blend ratios the water absorption showed increment tendency mainly due to the increase in DWGF, which is higher in fiber content which cause high number of hydroxyl groups existing in the fiber molecules, responsible to allow more water interaction due hydrogen bonding. Dough development time for wheat flour (control) is lower than the blended ones. This showed addition of more defatted wheat germ flour resulted more time to be developed this again basically due to increased amount of moisture content inside the water loving hydroxyl group which are present highly in the fiber part this as a result ended up the final dough development time to be higher as the more amount of defatted wheat germ blended similar findings with [25].

The control needed less dough stability time and has got the lowest farinograph quality number while higher farinograph quality number obtained for higher amount of defatted wheat germ flour proportion;

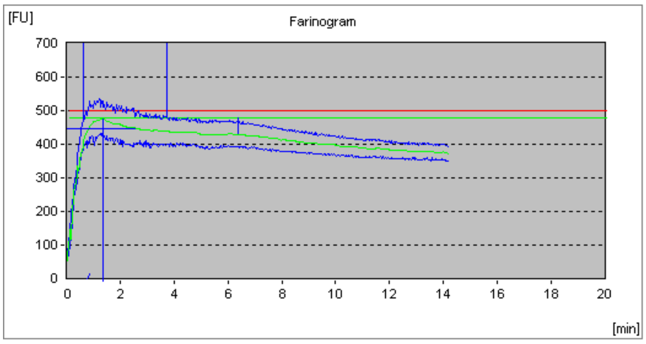

Figure 1: Farinograph values of control flour/ WF [min].

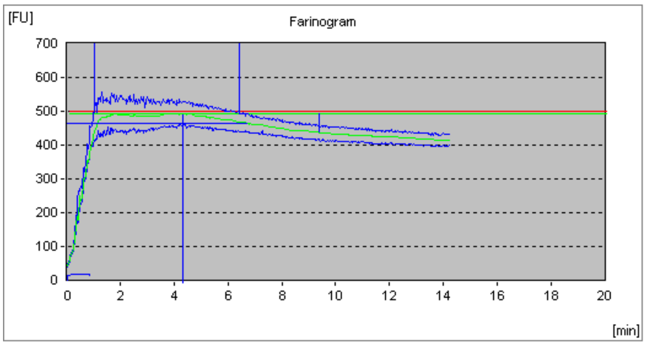

Figure 2: Farinograph value for BR_1 [min].

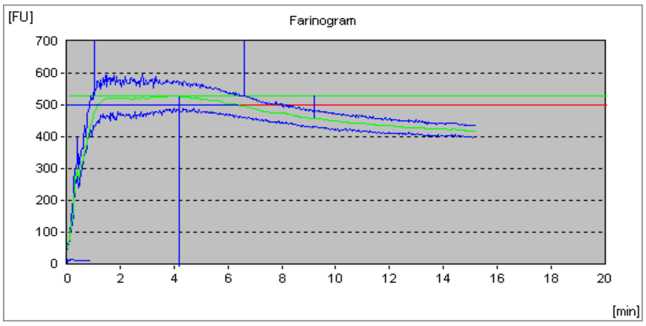

Figure 3: Farinograph result for BR_2 [min].

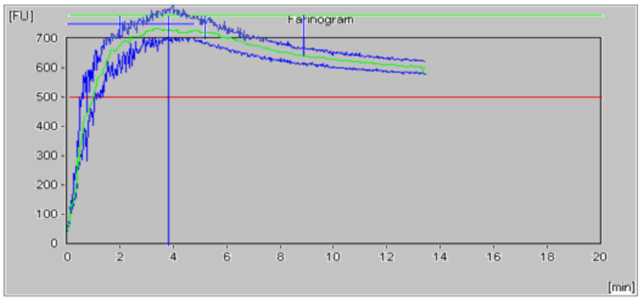

Figure 4: Farinograph result for BR_2 [min].

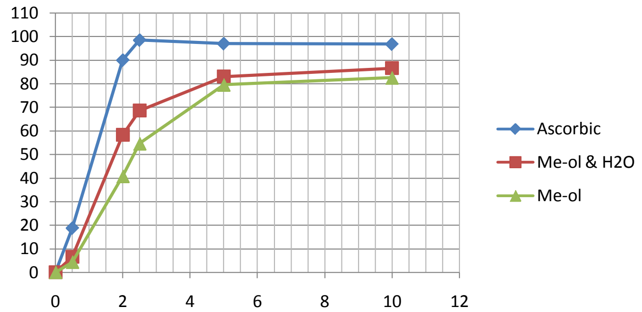

Figure 5: Free radical scavenging methanolic extract of wheat bran and control.

Flours	BD	WAC	OAC
WF	0.625 ± .003	0.78 ± 0.042	0.78 ± .04
BR_1	0.65 ± .028	0.87 ± .042	0.95 ± .021
BR_2	0.67 ± .008	1.07 ± 0.049	1.19 ± .028
BR_3	0.68 ± .014	1.98 ± 0.049	2.14 ± .042

All values are means of duplicate ± standard deviations

Where:- BD=bulk density, WAC=water absorption capacity and OAC=oil absorption capacity

WF=Wheat flour; BR_1=90% WF and 10% DWGF; BR_2=85% WF and 15% DWGF; BR_3=80% WF and 20% DWGF

Table 2a: Functional properties of flours.

signifying that the flour had high water absorption capacity [26]. The blended ones desired more time of stability. Though longer stability means easier handling for the baker and less possibility of over mixing, the dough with an increase in defatted wheat germ flour ratio resulted having difficulty to achieve stability with in short period of time as that of the control (Figures 1-4). This is mainly due to excellent amount of protein content present inside the defatted wheat germ flour. And this might be due the difference in protein content and quality of flours which is similar finding with [27].

Functional properties of flours

Functional properties are parameters that determine the application and use of food material for various food products including water absorption capacity, bulk density, and oil absorption capacity. The wheat flour and blend of DWGF analyzed for their functional properties for the formulation of value added cookies. The mean values for bulk density, water and oil absorption capacities were shown in Table 2a.

Bulk density of wheat flour and the blended composites flours indicated that the highest bulk density was obtained by BR_3, BR_2, BR_1

and finally WF. Having higher bulk density of composite flour exhibit better compactness and possible mixed effect caused by the interaction of the molecules of the DWGF and WF; and implies that a denser packaging material may be required for this product. Bulk density gives information on the porosity of a product and can influence the choice of package and its design [28]. The water absorption capacity (water holding ability) of flour samples showed higher water absorption capacity as the blend ratio of DWGF increased. This might be due the presence of high protein, crude fiber and higher amounts of hydrophilic constituents in DWGF. Higher WAC of the composite flour may be attributed to their higher protein contents. Water absorption capacity is a critical function of protein in various food products like soups, gravies, doughs and baked products [29].

Oil absorption capacity (OAC) is another vital functional property of flour hence it's excellent in enhancing the mouth feel while preserve the flavor of food products. The removal of fat from the samples exposes the water binding sites on the side chain groups of protein units previously blocked in a lipophilic environment thereby leading to an increase in WAC and oil absorption in proportion to the protein contents of the flour. Similar observation has been reported by [30]. As the result showed the oil absorption of defatted wheat germ blended flour was higher than those of wheat flour; this might be due to DWGF may have more hydrophobic proteins demonstrating superior binding of lipids. Hence the major chemical component affecting oil absorption capacity is protein, which is composed of both hydrophilic and hydrophobic parts. This on the other hand shows DWGF with the higher blend ratio improved mouth feel and preserve the flavor of the value added cookies produced [31].

Effect of blend ratio and baking temperature on moisture content

The effect of blend ratio and baking temperature on moisture content, protein, crude fiber and ash were analyzed and compiled in Table 2a. As baking temperature increased moisture content obviously declined and the amount of blend ratio increased for same baking temperature the moisture content increased significantly ($P<0.05$). This is caused by the greater number of hydroxyl existed inside the fiber structure that allow more water interaction through hydrogen bonding; similar findings were obtained by [32].

Effect of blend ratio and baking temperature on crude protein content

Baking temperature and blend ratio affected the protein content of cookies. The average protein content was declined slightly with increasing in baking temperature. This is either due to protein denaturation resulted due to the effect of high temperature, or Maillard reaction (a reaction by free amino groups of amino acids and sugars). Similar result found when studied the effect of heat stress on protein content [33]. The value of protein increased significantly ($P<0.05$) with every increment of blend ratio this is because the more amounts of amino acids are present in each increment in blend ratio. The amount of water associated to proteins is closely related with its amino acids profile and increases with the number of charged residues, hydrophobicity, pH, temperature, ionic strength and protein concentration [34].

Effect of blend ratio and baking temperature on crude fiber

Now a day number of people in the world boost up consumption of dietary fiber intake by accepting the fact it's capable of reducing blood cholesterol levels, occurrence of colon cancer even best for weight loss hence it is the indigestible part and feels the belly full without leaving

	% Moisture	% Protein	% Fiber	% Ash
BWFT$_1$	7.14 ± 0.04^{c}	9.85 ± 0.04^{d*}	1.84 ± 0.04^{c**}	0.81 ± 0.06^{C***}
BWFT$_2$	7.08 ± 0.04^{d}	9.35 ± 0.08^{d*}	1.79 ± 0.06^{d**}	0.79 ± 0.09^{c***}
BWFT$_3$	7.01 ± 0.04^{b}	9.17 ± 0.06^{d*}	1.71 ± 0.05^{d**}	0.74 ± 0.04^{c***}
BR1T$_1$	7.52 ± 0.04^{b}	13.83 ± 0.09^{c*}	2.23 ± 0.08^{b**}	1.28 ± 0.03^{b***}
BR1T$_2$	7.28 ± 0.05^{c}	13.35 ± 0.10^{c*}	2.17 ± 0.08^{c**}	1.24 ± 0.06^{b***}
BR1T$_3$	6.87 ± 0.07^{b}	12.87 ± 0.06^{c*}	2.08 ± 0.10^{c**}	1.19 ± 0.11^{b***}
BR2T$_1$	7.64 ± 0.04^{a}	14.43 ± 0.06^{b*}	2.93 ± 0.13^{a**}	1.38 ± 0.05^{b***}
BR2T$_2$	7.49 ± 0.05^{b}	14.29 ± 0.08^{b*}	2.84 ± 0.04^{b**}	1.31 ± 0.06^{ab***}
BR2T$_3$	6.99 ± 0.06^{b}	14.19 ± 0.04^{b}	2.77 ± 0.07^{b**}	1.23 ± 0.07^{b***}
BR3T$_1$	7.69 ± 0.02^{a}	15.88 ± 0.18^{a*}	3.05 ± 0.11^{a**}	1.55 ± 0.06^{a***}
BR3T$_2$	7.65 ± 0.06^{a}	16.78 ± 0.11^{a*}	3.10 ± 0.04^{a**}	1.51 ± 0.09^{a***}
BR3T$_3$	7.47 ± 0.04^{a}	15.08 ± 0.12^{a*}	2.97 ± 0.03^{a**}	1.47 ± 0.07^{a***}

$^{a-d}$All values are means of duplicate ± SD on dry weight basis Means followed by different superscript within the same row differ significantly ($P<0.05$).

Where BWFT$_1$=biscuit baked from wheat flour at T$_1$ (150°C), BWFT$_2$=biscuit baked from wheat flour at T$_2$ (180°C), BWFT$_3$=biscuit baked from wheat flour at T$_3$ (210°C), BR1T$_1$=biscuit baked from (90% wheat flour and 10% defatted wheat germ flour) at 150°C, BR1T$_2$=biscuit baked from (90% wheat flour and 10% defatted wheat germ flour) at 180°C, BR1T$_3$=biscuit baked from (90% wheat flour and 10% defatted wheat germ flour) at 210°C, BR2T$_1$=biscuit baked from (85% wheat flour and 15% defatted wheat germ flour) at 150°C, BR2T$_2$=biscuit baked from (85% wheat flour and 15% defatted wheat germ flour) at 180°C, BR2T$_3$=biscuit baked from (85% wheat flour and 15% defatted wheat germ flour) at 210°C, BR3T$_1$=biscuit baked from (80% wheat flour and 20% defatted wheat germ flour) at 150°C, BR3T$_2$=biscuit baked from (80% wheat flour and 20% defatted wheat germ flour) at 180°C, BR3T$_3$=biscuit baked from (80% wheat flour and 20% defatted wheat germ flour) at 210°C.

Table 2b: Effect of blend ratio and baking temperature on proximate composition.

the individual obsessed. According to [35] daily intake of dietary fiber is 25 gm/day. Thus it's advantageous to use the byproduct DWGF with almost no cost. From Table 2b baking temperature of the cookies didn't have that much significant effect on the crude fiber content of the cookies, however cookies were found significantly affected by blend ratio ($P<0.05$). As the blend ratio of the composite flour used increased the amount of crude fiber content also increased. Therefore supplementation of wheat flour with defatted wheat germ flour could be one alternative to make our food nutritionally loaded. Similar findings were obtained [36].

Effect of blend ratio and baking temperature on ash content and minerals

Ash is mineral content of foods, determined by combustion of the sample under defined conditions and weighing of the residue. The ash content of the cookie was found significantly influenced by the blend ratio ($P<0.05$) but not by baking temperature. Increasing in the blend ratio of DWGF in the respective blend ratios similarly increased the amount of ash in the last product. This could be the result of higher amount of ash content in defatted wheat germ flour than wheat flour initially. Ash was found not significantly influenced by baking temperature and similar finding with [37] was obtained.

According to [38] minerals, unlike vitamins and amino acids, cannot be destroyed by exposure to heat this could be the reason that baking temperature was not influence ash content of the cookie significantly. Therefore amount of minerals presented in the cookies is significantly affected ($P<0.05$) by blend ratio. This is basically true hence the defatted wheat germ flour has got magnificent amount of minerals than that of the control. A similar finding was observed [36].

Effect of blend ratio and baking temperature on physical

properties of cookies

The effect of blend ratio and temperature showed a significance difference in the weight of cookies. As the blend ratio of the cookie increased the weight of the cookies also increased this could be majorly as a result of imbitions of water (higher water absorption owing to high protein content in DWGF) or could be higher bulk density of DWGF in each proportion increment that is similar finding with [39]. However, there is an adverse effect of temperature on weight loss of the cookies this might be due to the up taken of high amount of moisture content in every raise in temperature.

As the supplementation of defatted wheat germ increased the diameter and height of the cookies resulted decreased. This might be due to the different flour quality of the blended flours (presence of high fiber). When there was a raise in temperature the height of the cookie showed slight diminish this could be due to reduction by volume of cookies due high amount of moisture up taken by the raise in temperature. A similar decreased in diameter was also reported [16,37] wheat, quality protein maize and carrot. From the Tables 3 and 4 spread ratio decreased with an increase in blend ratio. Hence it's an indication of the viscous property of dough and influenced by the recipe, ingredients, procedures and conditions used in biscuit production [40] reported that rapid partitioning of free water to hydrophilic sites during mixing increased dough viscosity, thereby limiting cookie spread; or a decrease in spread factor and thickness was due to the increase in amount of protein, as addition of soy flour which could attribute to higher protein content of soy flour as reported by [41]. However, it has been suggested that spread ratio is affected by the competition of ingredients for the available water, by flour or any other ingredient, which absorbs water during dough mixing, will decrease it [42].

Flours	Minerals (mg/100 g)			
	Mg	P	Ca	K
WF	25.65 ± 1.34[d]	179.15 ± 1.20[d]	39.55 ± 1.06[a]	130.1 ± 0.85[d]
BBR_1	46.2 ± 0.98[c]	207.85 ± 0.35[c]	40.4 ± 0.28[a]	213.8 ± 0.42[c]
BBR_2	54.5 ± 0.84[b]	216.7 ± 0.57[b]	40.6 ± 0.42[a]	235.0 ± 0.28[b]
BBR_3	61.95 ± 1.34[a]	232.5 ± 0.84[a]	41.1 ± 0.28[a]	278.7 ± 0.84[a]

All values are means of duplicate ± SD
Means followed by different superscript within the same column differ significantly (P<0.05).

Table 3: Mineral composition of biscuits at different blend proportions.

	Weight (g)	Diameter (cm)	Thickness/ Height (mm)	Spread ratio
$BWFT_1$	5.43 ± 0.01[d]	4.52 ± 0.07[a]	0.53 ± .001[a]	8.69 ± 0.05[a]
$BWFT_2$	5.37 ± .007[d]	4.40 ± 0.04[a]	0.52 ± 0.04[a]	8.63 ± 0.08[a]
$BWFT_3$	5.30 ± 0.01[c]	4.39 ± 0.06[a]	0.51 ± 0.01[a]	8.61 ± 0.07[a]
$BR1T_1$	6.44 ± 0.02[c]	3.88 ± 0.10[b]	0.522 ± 0.01[b]	7.46 ± 0.05[c]
$BR1T_2$	6.29 ± 0.02[c]	3.850 ± 0.08[b]	0.51 ± 0.07[b]	7.54 ± 0.04[c]
$BR1T_3$	6.29 ± 0.04[b]	3.840 ± 0.04[b]	0.50 ± .004[b]	7.68 ± 0.06[bc]
$BR2T_1$	6.74 ± 0.01[b]	3.76 ± 0.06[bc]	0.49 ± .0014[c]	7.67 ± 0.07b
$BR2T_2$	6.52 ± 0.02[b]	3.800 ± 0.01[b]	0.51 ± 0.02[c]	7.65 ± 0.09[c]
$BR2T_3$	6.42 ± 0.01[b]	3.74 ± 0.07[bc]	0.48 ± .001[c]	7.65 ± 0.03[c]
$BR3T_1$	7.06 ± 0.04[a]	3.63 ± 0.08[c]	0.48 ± .002[d]	7.72 ± 0.07[b]
$BR3T_2$	6.87 ± 0.06[a]	3.610 ± 0.05[c]	0.47 ± 0.02[d]	7.85 ± 0.06[b]
$BR3T_3$	6.8 ± 0.014[a]	3.610 ± 0.09[c]	0.46 ± 0.01[d]	7.84 ± 0.08[b]

[a-d] All values are means of duplicate ± standard deviations
Means followed by different superscript within the same column differ significantly (P<0.05).

Table 4: Effect of blend ratio and baking temperature on spread ratio.

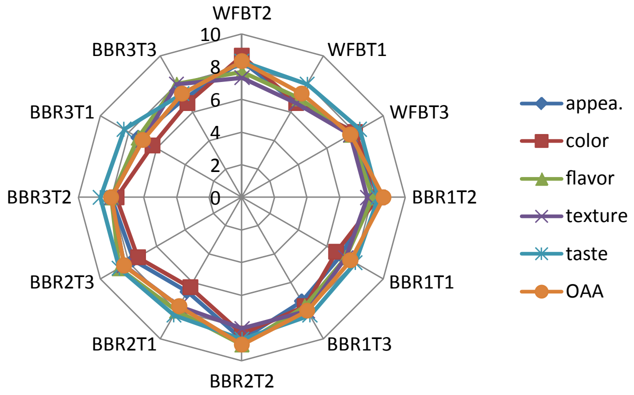

Figure 6a: Sensory quality evaluation of cookies.

Total phenolic content of wheat bran

Total phenolic content of wheat bran using different temperature range differed (1.04, 2.15, 3.58 and 3.68) mg of GAE/g for temperatures 40, 80, and 60°C using absolute and solvent methanol for extraction. Hence, higher total phenolic compounds were extracted by using organics solvent where the polarity was modified with water. These mixtures become ideal and selective to extract bioactive components of phenolic compounds [43]. The extraction temperature was raised till some degree in order to release more phenolic compounds [44]. The difference in total phenolic content among each extraction may be due to the variation in heat labile nature of cereal bran [19] and type of solvents used. The aqueous methanol was better than the absolute one due to the fact that phenolics are often extracted in higher amounts in more polar solvents such as aqueous methanol as compared with absolute methanol [45,46].

Antioxidant activity of wheat bran

DPPH (2,2-diphenyl-1-picrylhydrazyl) radical are widely used as the model system to investigate scavenging activities of numerous natural compounds. DPPH radical is scavenged by anti oxidants through donation of proton forming the reduced DPPH. The color changes from purple to yellow after reduction, which can be quantified by decrease of absorbance at wave length 517 nm. The scavenging effect of ascorbic acid, absolute and aqueous methanol extract of wheat bran at 60°C extraction on the DPPH radical was 96.8%, 86.6%, and 82.5% at a concentration of 10mg/ml. The capacity of wheat extract to scavenge the stable DPPH radical is shown in Figure 5. Where blue, red and green are percentage inhibition capacities for ascorbic acid, methanol solvent and absolute methanol with IC_{50} value (1.43, 1.75, and 2.13) mg/ml; respectively. Aqueous mixtures containing methanol is one of the most suitable solvents [47].

Sensory quality evaluation of value added products

The sensory quality evaluation of cookies baked at variety of blend ratio and baking temperature for appearance, color, flavor, texture, taste and overall acceptability conducted by the panelist result shown in Figure 6a. The overall acceptability of cookies was influenced by both blend proportion and baking temperature. The uppermost score of judgment on over all acceptability was observed for 15% blend ratio at 180°C (BR_2T_2), while the least one was BR_3 at T_1. This might be due

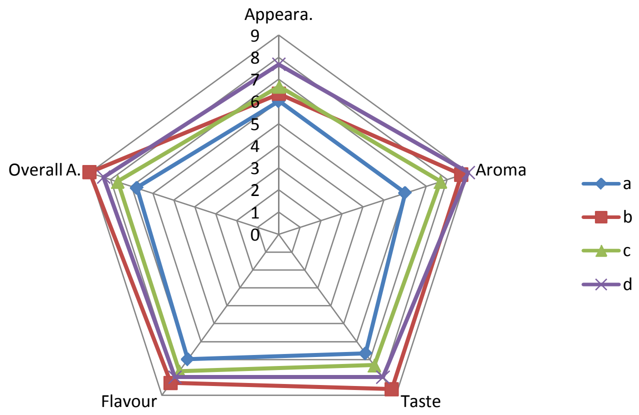

Figure 6b: Sensory quality evaluations of tea substitute.
Where a=unflavored tea b=funneled tea c=mint tea d=cinnamon tea

to the enhanced flavor and enriched texture for end product imparted by the defatted wheat germ flour. This finding is not in agreement with [48] and this could be mainly due to method used for defatting wheat germ flour and perception of acceptance.

A 9-point hedonic scale test was used for sensory quality evalution of cookies and tea subsitute (Figure 6b). The flavored samples were showed better sensory quality than that of unflavored one which is expected as accustomed in normal black tea. Result of tea substitute using additives of funnel seed and cinnamon was exceptionally adored by the pannalists.

Conclusions

This study was primarily aimed to investigate the possibilities of investigation underutilized byproducts from wheat milling industries; with the intention of developing value added products (cookies and tea substitute) respectively. Appropriate blend ratio, baking temperature and their combination with their impact on the functional and rheological property of flours, proximate and sensory quality of the newly formulated product. Tea substitute from wheat bran demonstrated better antioxidant activity and phenolic content. The research findings revealed that wheat flour supplemented with defatted wheat germ flour was more than adequate to be used as enrichment of wheat flour. Hence DWGF showed a significantly different (P<0.05) in nutritional value. Rheological properties (Dough development time, dough stability, farinograph quality number) of dough measured by farinograph demonstrated that acceptable range of dough rheology parameters were up to the level of 15% blend ratio. The 15% blended cookies baked at temperature of 180°C (BR_2T_2) resulted acceptable sensory attributes, better nutritional composition and quite not destructively affected by temperature and blend ratio.

The wheat bran extracted using absolute and solvent methanol for determination of total phenolic content using Folin-Ciocalteu assay and antioxidant activity using DPPH scavenging assay at (40, 60 and 80)°C. Gallic acid and ascorbic acid were used as a control for both assays respectively. A higher total phenolic content (3.68 mg/g) of gallic acid equivalent was investigated at a temperature of 60°C using solvent methanol. Percentage inhibition capacity for ascorbic acid, methanol solvent and absolute methanol with IC_{50} values were 1.43, 1.75, and 2.13 mg/ml; respectively. The tea substitute made from wheat bran flavored with funnel seed and cinnamon has been resulted enhanced sensory acceptance. The main byproducts of wheat milling industries can be used for the development of value added products in the near future in the Ethiopian context.

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