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Evaluation of physicochemical and functional properties of composite flours blended with different ratios of moringa leaves powder

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Abstract
The goal of this research was to evaluate at the functional and physicochemical attributes of composite flours made from *Moringa oleifera* leaf powder, flaxseed powder, finger millet flour, barley flour, pearl millet, sorghum flour, oat flour, and semolina. The flour samples were blended in a complete randomised design (CRD) to create composite blends at five different amounts of Moringa leaf powder (2, 3, 4, 5, and 6 percent), yielding 20 samples. The statistical analysis of collected data was used to select five generally accepted composite flour samples (Wheat flour, Moringa oleifera leaf powder, flaxseed powder, finger millet flour, barley flour, pearl millet, sorghum flour, oat flour, and semolina) with ratio of T_0 = 100:0:0:0:0:0:0:0:0, T_1 = 92:2:1:1:1:1:1:1:0, T_2 = 84:3:2:2:2:2:2:2:1, T_3 = 76:4:3:3:3:3:3:3:2, T_4 = 68:5:4:4:4:4:4:4:3 and T_5 = 60:6:5:5:5:5:5:5:4 respectively. Standard procedures were used to assess the functional and physicochemical qualities of all samples. Water absorption capacity of the composite flours ranged from 109.71 percent to 138.71 percent, Oil absorption capacity from 127.71 percent to 176.85 percent, Bulk density 0.47 g/cc to 0.49 g/cc, swelling capacity 29.23 g/ml to 31.00 g/ml, Emulsion Activity (EA) and Emulsion Stability from 40.58 to 45.45 percent, and from 40.28 to 44.12% When moringa leaf powder and other millet flours were added to the blends, the functionality of the composite flours, such as water absorption, oil absorption capabilities and bulk density, improved. According to the results of physiochemical properties the moisture content of composite flours ranged from 7.94 to 8.37 percent, ash content 1.98 to 5.22 percent, fat content 2.73 to 6.97 percent, crude fibre 0.56 to 1.17 percent, optical density 0.082 to 0.442, pH and acidity 6.45 to 7.15 and 0.023 to 0.039 percent, respectively. When moringa leaf powder was added to the flour blends, these qualities were demonstrated to improve. As a consequence, composite flours made from *moringa oleifera* leaf powder and other millet flours will be more nutritious than whole wheat flour in terms of functionality and physicochemical attributes, and will be useful in food formulations such as bakery products.

Keywords: Moringa leaf powder, composite flours, Millet flour, bakery products, physicochemical

Introduction
Moringa oleifera is known as the "wonder tree" because of its high protein, vitamins, and mineral contents. Apart from its usage in food, medicine, and industry, it can also be employed in the preparation of comprehensive health foods (Khalafalla *et al*., 2010) [10]. Because of its nutritional and medicinal properties, it is commonly referred to as the "tree of life" or "miracle plant." Researchers are increasingly interested in the development of food products made using composite flour, particularly in the production of bakery goods and pastries. This article focuses on the use of composite flour in the production of food products, specifically biscuits, and examines its impact on proximate features and nutritional values after various modifications have been made. It is also reported that wheat flour is blended with diverse sources of tubers, legumes, cereals, and fruit flour in varied amounts to generate a range of food products. It was discovered that food products manufactured with composite flour have similar properties to goods made with full-wheat flour. The functional and physicochemical features of raw blended flour, as well as the health benefits of percentage blending, can be visible in the finished product as a result of using composite flour. Overall, composite flour is a promising new method to use remarkable foods, as the usage of composite flour resulted in products with varying features and improved quality, depending on the types and percentages of flours used in the formulation.

In times of wheat scarcity, whether due to climatic or economic factors, biscuits have traditionally been made with blends of wheat and other flours, now known as composite flours. Millet flours, moringa powder, potato, and yam are some of the elements used to make composite flour. Composite flours are not the same as the ready-mixed flours that millers and bakers are accustomed with. The fundamental physico-chemical properties of food components are functional properties, which reflect the complex interaction between their composition, structure, molecular conformation, and physico-chemical properties, as well as the nature of the environment in which they are associated and measured (Kinsella, 1976) [4]. Functional features are needed to assess and maybe forecast how new proteins, fats, fibres, and carbs will behave in specific systems, as well as to show whether such protein can be utilised to supplement or replace conventional protein (Mattil, 1971) [5]. The biscuits on the market are made from wheat flour (whole/refined), which lacks high-quality protein due to a lysine shortage, as well as dietary fibre. Moringa leaf powder, flaxseed powder, finger millet flour, barley flour, pearl millet, sorghum flour, oat flour, and semolina are all high-protein, high-vitamin, and high-mineral foods. Energy, protein, iron, calcium, and numerous vitamins are among significant components found in bakery products. Most bakery goods can be easily enriched and fortified to fulfil the unique nutritional demands of target groups and undernourished portions of the population. Bakery items can also be tailored to fulfil consumers' unique medicinal requirements (Oduro *et al*., 2008) [19]. This research reveals a commercially viable method of incorporating nutritional value into moringa blended cookies, which can help to alleviate malnutrition and other key macro and micronutrient deficiencies in the population. The objective of the present study was to develop the fibre rich, vitamin rich and protein rich cookies which would serve as nutritious products. In this sequence, present study was conducted to develop nutritious cookies from composite flours incorporated with Moring leaf powder.

Materials and Methods

The experiments were conducted in Bakery Lab and Food Analysis Laboratory in the College of post harvest technology. Sardar Vallabh Bhai Patel University of Agriculture and Technology, Meerut (India).

Sample collection

At first the Moringa leaves were sorted to reject unwanted, over matured and insect affected portions of the leaves. Then they were thoroughly washed with water and shade dried for one week. Then the dried leaves were ground to fine powder and kept at airtight container. Raw materials *viz*., flaxseed powder, finger millet flour, barley flour, pearl millet, sorghum flour, oat flour, and semolina etc. were procured from the local market for the present study.

Physicochemical analysis of composite flours

There was all 6 treatments wherein 0, 2, 3, 4, 5 and 6% moringa leaf powder was added to the composite flours. The method described by AOAC (2012) [9] was used for the determination of moisture content. Protein content was estimated by determining total nitrogen using standard Micro-Kjeldhal method, and multiplying the amount of N by 6.25. Fat content was estimated by using Soxhlet extractor (AOAC, 2012) [9]. The crude fiber content was also estimated following AOAC (2012) [9]. The carbohydrate content was calculated as described by Emmanuel *et al*., (2012).

Analysis of Functional properties of composite flours

The swelling capacity, water absorption capacity (WAC %), oil absorption capacity (OAC %), emulsion activity (EA %), emulsion stability (ES %), and bulk density (g/cc) of flours were investigated. Okaka and Potter (1977) [6] devised a method for determining swelling capacity. The sample was filled to the 10 ml point in a 100 ml graduated cylinder. To make a total volume of 50 cc, distilled water was added. By inverting the cylinder, the top of the graduated cylinder was snugly covered and blended. After 2 minutes, the suspension was inverted again and left to stand for another 8 minutes, during which time the volume occupied by the sample was measured. Sosulski *et al*., (1976) [7] method was used to determine the flours' water absorption capability. Allow one gram of material to soak in 10 mL distilled water for 30 minutes at room temperature (30 2 °C), then centrifuge for 30 minutes at 3,000 rpm or 2000 g. The percentage of water bound per gram flour was used to test water absorption. Sosulski *et al*., (1976) [7] method was also used to determine the oil absorption capacity. Allowed one gram of material to soak in 10 mL soybean oil (Sp. Gravity: 0.9092) for 30 minutes at room temperature (30 2 °C), then centrifuge for 30 minutes at 300 rpm or 2000 g. The percent water bound per gram flour was used to measure water absorption. The emulsion activity and stability by Yasumatsu *et al*., (1972) [8] described and followed as method for the emulsion in present study (1 g sample, 10 mL distilled water and 10 ml soybean oil) was prepared in calibrated centrifuge tube. The emulsion was centrifuged for 5 minutes at 2000 g. Emulsion activity was calculated as the ratio of the height of the emulsion layer to the total height of the mixture. After heating the emulsion in a calibrated centrifuged tube at 80 °C for 30 minutes in a water bath, chilling for 15 minutes under running tap water, then centrifuging at 2000 g for 15 minutes, the emulsion stability was determined. The emulsion stability was calculated as the ratio of the height of the emulsified layer to the entire height of the mixture, represented as a percentage. The volume of 100 g of the flour was measured in a measuring cylinder (250 mL) after tapping the cylinder on a wooden plank until no visible decrease in volume was noticed, and based on the weight and volume, the apparent (bulk) density was calculated (Jones *et al*., 2000) [2].

Results and Discussion

Table 1 shows the results of the physicochemical properties of moringa leaf powder mixed composite flours. Different compositions and ratios of composite flours were created. Among all the flours, the moisture content of composite flours ranged from 7.94 to 8.37 percent. The control flour (T0) had the highest moisture content (8.37%), while the T5 composite flour had the lowest (7.94%). When comparing the moisture content of control and composite flours, it was discovered that composite flours had lower moisture content than control flours. The moisture content of composite flours declined as the proportions of other flours increased. The study revealed that moisture content of composite flours decreased with decrease in proportions of wheat. Similar trends were reported by Kaushal *et al*., (2012) [3]. They used the blends of taro, rice and pigeon pea flour which resulted in reduction of moisture content of composite flours.

Table 1: Physico-chemical composition of composite flours

Treatments	Moisture (%)	Ash (%)	Protein (%)	Fat (%)	Fiber (%)	Total Carbohydrate (%)	Acidity	pH	Optical Density
T0	8.376 ±0.000	5.217 ±0.001	9.15 ±0.017	2.77 ±0.020	4.14 ±0.024	74.530 ±0.003	0.027±0.000	7.17 ±0.012	0.085 ±0.002
T1	8.070 ±0.004	2.595 ±0.002	8.76 ±0.001	2.80 ±0.046	5.66 ±0.019	77.694 ±0.000	0.023±0.000	6.75 ±0.007	0.255 ±0.002
T2	8.233 ±0.004	2.156 ±0.001	11.83 ±0.003	3.53 ±0.035	6.17 ±0.012	74.247 ±0.000	0.023±0.000	6.69 ±0.009	0.345 ±0.001
T3	7.962 ±0.009	2.721±0.005	10.07 ±0.000	3.76 ±0.025	6.04 ±0.023	75.483 ±0.003	0.026±0.000	6.55 ±0.017	0.238 ±0.001
T4	8.320 ±0.003	1.975 ±0.006	10.51 ±0.001	4.86 ±0.010	6.58 ±0.012	74.356 ±0.020	0.029±0.000	6.45 ±0.009	0.197 ±0.001
T5	7.939 ±0.000	2.026 ±0.001	10.94 ±0.002	6.93 ±0.027	6.65 ±0.020	72.122 ±0.000	0.039±0.000	6.46 ±0.009	0.444 ±0.003

The ash level of composite flours ranged from 1.98 percent to 5.22 percent all across range. The wheat flour or control (T1) had the highest ash concentration (5.22%), whereas composite had the lowest (1.98%). (T4). When comparing individual flours to composite flours, it was discovered that individual flours had a higher ash concentration than composite flours. The ash level of composite flours is also affected by the weather, moisture content of the flour, ratio of various flours, and the texture of the flour. Among all the flours, the protein level of composite flours ranged from 8.76 to 10.96 percent. Composite flour (T5) had the highest protein level (10.96%), whereas wheat flour or control had the lowest (8.76%). (T0). The nutritional makeup of the distinct flours had an impact on the sample's protein content. Because wheat flour was replaced with other flours, the protein content of composite flours increased. The fat level of composite flours ranged from 2.73 percent to 6.97 percent across the board. Composite flour (T5) had the highest fat level (6.97%), whereas wheat flour or control had the lowest (2.73%). (T0). When individual flours were compared to composite flours, the fat content was found to be higher in composite flours than in controls, owing to the increased flaxseed proportion. Fat content of the sample is also affected due to moisture content and nutritional composition of the individual flours. The fat content of composite flours increased due to replacement of wheat flour with other flours and flaxseed powder.

The crude fiber content of composite flours ranged from 0.56 to 1.17 percent across the board. Composite flour (T2) had the highest crude fiber (1.17%), whereas composite flour (T1) had the lowest (0.56%). (T4). When comparing individual flours to composite flours, it was discovered that composite flours had more crude fiber than separate flours. The nutritional makeup of the separate flours has an impact on the sample's crude fiber. Due to the substitution of other flours for wheat flour, the crude fiber of composite flour rose. The carbohydrate content of composite flours ranged from 72.12 to 77.69 percent across all flours tested. The highest carbohydrate (77.69%) was observed in composite (T_1) while lowest (72.12%) in composite flour (T_5). Carbohydrate of the sample is also affected due to moisture content and nutritional composition of the individual flours.

Among all the flours, the optical density of composite flours ranged from 0.082 to 0.442. Composite flour (T5) had the highest optical density (0.442), whereas wheat flour or control had the lowest (0.082). (T0). When comparing individual flours to composite flours, it was discovered that individual flours had a higher optical density than composite flours. The nutritional composition of the separate flours has an impact on the sample's optical density. Due to the substitution of other flours for wheat flour, the optical density of composite flours increased. Among all the flours, the pH and acidity of composite flours ranged from 6.45 to 7.15 percent and 0.023 to 0.039 percent, respectively. The highest pH (7.51%) was observed in wheat flour or control (T_0) while lowest (6.45%) in composite flour (T_5) and highest acidity (0.039%) was observed in (T_5) while lowest in (0.023) in (T_2). The pH and acidity of the composite flours is also affected due to ratio of individual flours and nutritional properties.

Functional Properties of Composite Flours blended with *Moringa oleifera* Leaf Powder

The functional properties of composite flours made from wheat flour, millet flours, and Moringa oleifera leaf powder are shown in Table 2. The water absorption capacity of composite flours ranged from 109.71% in sample T2 to 138.71% in sample T0. The water absorption capacity of the flours decreased as the percentage of blended components were increased and Moringa oleifera leaf powder was added. The water absorption capacity of the flour blends was also significantly different ($p< 0.01$). Low-water-absorption composite flours generate thin meals, which are ideal for newborn formulas (Onweluzo and Nwabugwu, 2009) [12]. In food compositions, especially those requiring dough creation, water absorption is necessary. It is determined by the ability of protein in flours to physically bind with water (Ikpeme-Emmanuel *et al*., 2010) [13].

The flour blends' oil absorption capacity (OAC) ranged from 127.71 percent in sample T3 to 176.85 percent in sample T0. When wheat flour was mixed with other millet flours and Moringa oleifera leaf powder, OAC increased considerably ($p< 0.01$). Because fats improve mouth feel while keeping food flavour, oil absorption capacity is an important feature in food formulation (Adebowale *et al*., 2004) [14]. It's possible that the high OAC of the composite flour obtained by decreasing the wheat portion with millet flours, flaxseed, and moringa powder is related to the lipohilic protein in moringa, which has a great affinity for holding fat globules (Efuribe *et al*., 2018) [15]. Higher oil absorption of the composite flour is needed in food systems such as sausages production and meat analogues where optimum fat retentions are desired (Amadikwa *et al*., 2015) [16].

Table 2: Functional properties of moringa leaf powder blended composite flour

Treatments	Water absorption Capacity (%)	Swelling capacity (ml)	Oil absorption capacity (%)	Emulsion activity (%)	Emulsion stability (%)	Bulk density (g/cc)
T_0	138.71±0.028	31.01±0.008	176.85±0.044	42.423±0.000	41.18±0.016	0.467±0.001
T_1	129.68±0.000	29.74±0.008	130.54±0.012	45.153±0.014	40.27±0.009	0.473±0.001
T_2	109.73±0.000	29.67±0.010	174.23±0.032	40.587±0.014	41.18±0.017	0.478±0.001
T_3	118.39±0.009	29.51±0.012	127.71±0.000	43.287±0.012	44.14±0.018	0.483±0.001
T_4	129.91±0.009	29.24±0.013	168.40±0.009	44.137±0.006	44.11±0.012	0.486±0.001
T_5	123.65±0.00	28.78±0.010	168.39±0.012	45.457±0.014	44.13±0.000	0.491±0.001

The bulk density of the flour blends ranged from 0.47 to 0.49 gm/cc. The bulk density of the composite flours was remarkably similar ($p < 0.01$). The bulk density of the composite flours was found to be lower than the value of 0.54-0.72 g/ml reported by Eke-Ejiofor *et al*. (2018) [17] for acha, defatted soybean, and groundnut flour blends. It was also lower than the 0.61-0.67g/ml observed by Asaam *et al*., (2018) [18] for maize-soya pumpkin flour formulations. The bulk density of flours is critical in determining packaging and material handling requirements. Low bulk density flour blends are preferred because they contribute to lower dietary bulk, as well as convenience of packaging and transportation.
The composite flours' swelling capacity ranged from 29.23 g/ml in sample T4 to 31.00 g/ml in sample T0. Protein and starch content, as well as the amylase/amylopectin ratio of the starch, all affect swelling power, with low amylose content resulting in a high swelling power (Ikpeme-Emmanuel *et al*., 2010) [13]. Moringa oleifera leaf powder was added to the flour blends, and millets flou was substituted at a low level, resulting in lower swelling powers than the control wheat flour. The discrepancies in swelling power found could be attributable to molecular organisation changes inside the starch granules (Ikpeme-Emmanuel *et al*., 2010) [13].
Protein being the surface active agents can form and stabilize the emulsion by creating electrostatic repulsion on oil droplet surface (Kaushal *et al*., 2012) [3]. The Emulsion Activity (EA) and Emulsion Stability (ES) of flours are shown in Table 2. EA of different flours ranged between 40.58 and 45.45%. The highest EA 45.45% was in sample T5 and lowest 40.58% were observed in T3. Emulsion stability (ES) for different flours varied from 40.28 in sample T1 to 44.12% in sample T3, T4, and T5 (Table 2). The EA and ES of composite flours were shown to increase dramatically as the amounts of wheat flour were reduced. When extremely cohesive films are created by the absorption of stiff globular protein molecules that are more resistant to mechanical deformation, emulsion stability can be considerably improved (Graham and Phillips, 1980) [1]. Protein's key functional qualities in foods including comminuted meat products, salad dressing, frozen desserts, and mayonnaise include increasing emulsion activity (EA), emulsion stability (ES), and fat binding during processing. All of the composite flours had a good emulsion activity capacity.

Conclusion

The functional properties of wheat flour and composite flours such as swelling capacity, water absorption capacity, oil absorption capacity, emulsion activity, emulsion stability, and bulk density were improved with increase in the incorporation of moringa leaf powder and other flours with wheat flour. Physiochemical data revealed that nutritional value may be increased with increasing in the incorporation of moringa leaf powder, flaxseed powder and other flours with wheat flour in the formulation of bakery products. Incorporation of above flours to wheat flour specially moringa leaf powder would therefore be an effective method of cost reduction of bakery and other allied products and solving malnutrition problems in children in India and other developing countries.

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