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Physico-chemical and baking properties of wheat-sweet potato composite flour

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Abstract
Raw sweet potato was processed into flour and blended with wheat flour in different ratios to produce wheat-sweet potato composite flour. Breads were made from wheat- sweet potato composite flours and subjected to analysis of physical and sensory properties. Wheat: Sweet potato flour in the ratio 80:20 (WS) was selected as optimum on the basis of results obtained from physical and sensory evaluation of breads. Optimized composite flour was then compared with control (wheat flour) in terms of physico-chemical properties like bulk density, foaming capacity, swelling index, color, proximate composition etc. Optimized composite flour had significantly higher foaming capacity (27.33±1.15) and foam stability (62.37±0.67) in comparison with control (17.33±1.15 and 59.77±0.75 respectively). In terms of color, higher a* (2.12±0.03) and b* (15.52±0.21) values indicate yellowish red color for optimized composite flour. Significantly higher ash content and crude fiber of optimized composite flour indicate better nutritional properties than control.

Keywords: Composite Flour, Baking properties, Sweet potato

Introduction
Composite flours may firstly be defined as blends of wheat and non-wheat flours used for the production of breads, unleavened baked products, porridges, pastas and snacks; or secondly as wholly non-wheat flours used for the same purposes. Reasons behind mixing wheat with non-wheat flours are *economical* e.g. as in times of scarcity of wheat to reduce wheat imports as well as *nutritional* e.g. high protein content in wheat-soya composite flours.
Wheat flour for making bread has to be imported in many of the developing countries as the soil and climatic conditions do not permit wheat to be grown locally. Import of wheat in these developing countries has an increasingly adverse effect on the balance of trade. Thus, FAO and these developing countries were interested in possibility of replacing the wheat needed for making baked goods partially or wholly with flours of locally grown crops e.g. *cassava*, yam, sweet potato, soy, peanut, cereals (e.g. maize, rice). Composite flours caught attention of cereal scientists during 1960s and 1970s when bread consumption increased continuously in many of the developing countries. Moreover, recent discoveries in starch chemistry and baking technology made possible the use of composites or even gluten-free products for baking.
Sweet potato is the world's 7th most important food crop after wheat, rice, maize, potato, barley and cassava as reported by Horton (1988) [4] and Dayal *et al* (1991) [2]. Post-harvest losses for sweet potato are estimated to vary between 15-65% due to loss in fresh weight or root rot between one and four months of storage (Kone, 1991; Ray and Balaghopalan, 1997) [5, 9]. Sweet potato is used for both food (80% starch) and non-food industrial purposes (Zhu *et al*, 2014) [11]. Sweet potato flour (tray dried) contains 74.5% starch, 8.7% moisture, 1.56% ash, 2.3% protein, 9.4% dietary fiber (Sukhcharn Singh *et al*, 2008) [10].
Processing of sweet potato into flour helps prevent spoilage of excess produce as flours have longer shelf life. However, usage of sweet potato flour is unexplored. This study is an attempt to explore the use of sweet-potato flour as a component of wheat-sweet potato composite flour. Optimization of wheat-sweet potato composite flour for making bread will not only help in utilization of sweet potato flour but is also expected to result in mineral and dietary fibre fortification of wheat flour.

2. Materials and Methods
2.1. Raw materials
Sweet potato and wheat flour were procured from the local market of Puducherry, India.

All other chemicals used during the study were procured either from Fischer Scientific or Sisco Research Laboratories.

2.2. Preparation of Sweet potato flour
The method described by M. Van Hal (2000) [6] was used. After washing, peeling and shredding, hot water blanching was performed for 3-5 min at (80-82 ºC). Then the blanched shreds were subjected to tray drying at 65 ºC for 24 hrs followed by grinding and packing of flour in polyethylene pouches.

2.3 Experimental Design
Wheat-sweet potato composite flours (WS) were prepared in the ratios of 90:10, 85:15, 80:20 and 75:25 respectively. Wheat flour (100%) was referred to as control. Breads were prepared from sample flours and the physical and sensory characteristics of sample breads were compared with that of control. Results were analyzed to select the best ratio of wheat: sweet potato flour and the best ratio composite flour was compared with control for physico-chemical properties like water absorption capacity, oil absorption capacity, swelling index, bulk density, proximate composition and color.

2.4 Bread preparation and assessment of physical and sensory attributes.
Straight dough method described by Chauhan *et al* (1992) [1] was used for making bread.
The following baking formula was optimized for the study:

Table 1: Baking Formula

Ingredient	Amount (%)
Flour	57 %
Water	30 %
Sugar	6.4 %
Shortening	4.5 %
Salt	0.86 %
Yeast	1 %

For all the bread samples, The sensory attributes, including crust, aroma, shape, internal texture, taste, appearance and general acceptability, were evaluated by a semi trained 10-member panel, using a 9-point Hedonic scale with 1 representing the least score (dislike extremely) and 9 the highest score (like extremely) (Olaoye *et al*, 2006) [8].

Among physical parameters, weight, volume, specific volume and oven spring were calculated for each loaf. The loaf volume expressed was determined by the seed displacement method. The loaf was placed in a container of known volume into which millet seeds were run until the container was full. The volume of seeds displaced by the loaf was considered as the loaf volume.

2.5. Evaluation of physico-chemical properties and proximate composition
Physico-chemical properties of composite flour like bulk density, oil absorption capacity (OAC), water absorption capacity (WAC), swelling index, foaming capacity and foam stability were determined by the methods described by Mebpa *et al* (2007) [7]. Proximate principles i.e. moisture, fat, protein, dietary fibre and ash were determined by standard AOAC methods. L, a* and b* values were determined using lab scale Hunter Colorimeter.

3. Results and Discussion
3.1. Flour yield
Flour yield in case of sweet potato was 23.82%. A flour yield ranging from 17% to 38% have been reported for different field varieties of sweet potato (Gakonyo, 1993) [3]. Flour yield was calculated as the percentage of flour obtained from raw material taken in original form (without peeling). Flour yield was low due to more wastage during peeling as everything was done manually. Higher yield can be expected if all the unit operations are automated or semi- automated and flour production is carried out in an organized manner on an industrial scale.

3.2. Baking properties of Wheat-Sweet potato flour
Wheat-sweet potato flours in different ratios were subjected to baking test and physical as well as sensory properties of breads were analyzed.

3.2.1 Physical properties
The data obtained suggests that the physical characteristics of the bread are adversely affected with increasing levels of sweet-potato flour. Weight and volume of wheat-sweet potato breads reduced significantly upon increasing levels of sweet-potato flour. In comparison with the control, the specific volume decreased from 2.95±0.01 for S1 to 2.43±0.01for S4. The reason for decline in specific volume is clearly the decreasing level of gluten with increasing levels of sweet-potato flour. Oven spring also reduced significantly with increasing dilution as shown in Table 1. Mebpa *et al* (2007) [7] have also reported that beyond 5% level of wheat flour dilution, the oven spring and specific loaf volume of wheat-plantain breads reduced significantly in comparison to the control values.

Table 2: Physical characteristics of Wheat- Sweet potato bread

Parameters/Sample	Control (100:00)	WS1 (90:10)	WS2 (85:15)	WS3 (80:20)	WS4 (75:25)
Weight (g)	270.17±.03	268.22±0.02	256.29±0.12	246.36±0.07	240.8±0.01
Volume (cc)	796.5±1.57	754.61±1.54	690.26±4.22	647.91±4.10	586.48±0.5
Specific volume (cc/g)	2.95±0.01	2.81±0.01	2.69±0.01	2.63±0.02	2.43±0.01
Oven Spring (cm)	1.98±0.03	1.84±0.03	1.57±0.02	1.48±0.03	1.38±0.01

All values are means of triplicate determinations± standard deviation (SD)

3.2.2 Sensory Evaluation

Table 3: Sensory evaluation of wheat- sweet potato bread

Sample/Parameter	Appearance	Crust	Aroma	Internal Texture	Taste	Overall Acceptability
Control (100:0)	7.55±.07	6.55±.07	6.35±.07	7.70±.14	7.45±.07	7.35±.07
WS1 (90:10)	7.15±.07	6.60±.14	7.05±.07	7.7±.07	7.35±.07	7.25±.07
WS2 (85:15)	6.70±.014	6.60±.28	7.15±.07	7.35±.07	7.15±.07	7.10±.00
WS3 (80:20)	6.75±0.07	6.55±.21	7.15±.07	7.15±.14	7.05±.21	7.1±.21
WS4 (75:25)	5.80±.014	6.05±.07	6.25±.07	6.20±.14	6.55±.07	6.05±.07

All values are means of ten determinations± standard deviation (SD)

The data obtained from sensory evaluation of bread samples confirms the decline in quality characteristics of bread with increasing levels of sweet-potato flour. Crust appearance was almost comparable to control for all samples but taste and internal texture of bread deteriorated upon increasing levels of sweet-potato flour. In terms of overall acceptability, S1 was found to be closest to the control whereas satisfactory sensory attributes were achieved till S3 (80:20) dilutions. Internal texture of bread also deteriorated upon increasing levels of sweet-potato flour. Further dilution of wheat flour resulted in significant decline in the acceptability of bread. And thus on the basis of physical characteristics and sensory evaluation, S3 was selected as the most satisfactory for making bread.

Fig 1: Visual appearance of control and sample breads

3.3. Physico-chemical properties of optimized composite flour

Bulk density is an important characteristic of flour as it is directly related to the requirement of storage area as well as transportation costs. Higher bulk density is desirable in case of flour as it helps in reducing the logistics cost. Bulk density of optimized composite flour was lower than that of control which indicates the requirement of larger storage area for optimized composite flour.

Table 4: Physico-chemical properties of optimized composite flour

Physico-chemical properties	Control	Wheat: Sweet potato (80:20)
Bulk Density (cc/g)	0.70±.001	0.67±.005
Swelling Index	1.73±.01	1.65±.01
Foaming Capacity (%)	17.33±1.15	27.33±1.15
Foam Stability (%)	59.77±0.75	62.37±0.67
Water Absorption Capacity (%)	62.67±0.29	69.17±1.44
Oil Absorption Capacity (%)	124.83±0.29	60.83±1.44

All values are means of triplicate determinations± standard deviation (SD)

Swelling index is the capability to absorb water and increase in volume. It directly affects the dough and baking properties. Swelling index of optimized composite flour was lower than that of control which might be the reason behind poor baking performance of wheat-sweet potato composite flour. Foaming capacity is a measure of the ability of the flour to produce foams with solvents. Significant difference was observed between control and sample values with higher value in case of wheat-sweet potato composite flour i.e. 27.33±1.15. Mebpa *et al* (2007) [7] reported similar increasing trend in case of wheat- plantain composite flour. The foam stability of WS (62.37±0.67) was significantly higher than that of control and it may be concluded that optimized composite flour may fare better than control in food applications where foaming capacity and stability are desirable. Water absorption and oil absorption capacity of optimized composite flours were higher than that of control but in the range as reported by previous researchers.

3.4. Proximate composition of optimized composite flour

Table 5: Proximate composition

Parameters	Control	WS (80:20)
Moisture (%)	11.32±0.02	11.24±0.02
Ash (% d.b.)	0.45±0.01	1.86±0.01
Fiber (% d.b.)	0.81±0.01	1.1±0.02
Protein (% d.b.)	12.84±0.02	11.20±0.03
Fat (% d.b.)	0.97±0.01	0.86±0.02
Carbohydrate (% d.b.)	73.57±0.02	73.63±0.04

All values are means of triplicate determinations± standard deviation (SD)

Moisture content of flour is important in predicting its shelf stability. Higher the moisture content, more is the proneness of flour to microbial attack and vice versa. Moisture content of optimized composite flour was significantly lower than that of control indicating a higher shelf life. Also, the ash content of wheat- sweet potato flour is significantly higher than that of control. Higher mineral content of sweet potato may be the reason behind this increase in ash content. Thus, substitution of wheat flour with sweet potato flour is a nice option for its mineral fortification. Crude Fiber helps retain water and also improves digestibility. In comparison to Control, it increased significantly in the composite flours. Crude Fiber of optimized composite flour (1.1±0.02) is significantly higher than that of control flour (0.81±0.02). Olaoye *et al* (2006) [8] also reported improvement of nutritional attributes of wheat flour upon substitution with plantain and soyabean flours. Carbohydrate content was almost equal but protein and fat content were lower in case of optimized composite flour. Overall, substitution of sweet potato flour results in improvement of nutritional coefficient of wheat flour.

3.5. Colour of optimized composite flour

Color is an important factor in flour selection for bread and other bakery products and usually white colored refined wheat color is given preference. L*, a* and b* values were measured for control, and WS (wheat-sweet potato composite flour). L* (lightness) value reduced significantly from control (91.06±0.76) to WS (85.51±0.02) to WP (81.79±0.30). Color parameter a*, indicative of the redness of sample, was significantly higher in case of WS (2.12±0.03). Color parameter b*, indicative of the yellowness of sample was also significantly higher in case of WS flour. Further studies on improving the colour of composite flours through bleaching etc. are required to overcome this drawback of composite flours.

Table 6: Colour values of optimized composite flour and control

Sample	L*	a*	b*
Control	91.06±0.76	0.12±0.01	9.17±0.42
WS (80:20)	85.51±0.02	2.12±0.03	15.52±0.21

All values are means of triplicate determinations± standard deviation (SD)

4. Conclusion

This study helped in determining the optimum level of sweet potato flour which can be blended with wheat flour for making breads. Certain physico-chemical properties like WAC, OAC, Foaming capacity etc. were found to be better in case of optimized composite flour. Optimized composite flour contains higher mineral and dietary fibre content when compared to wheat flour. However, color of the optimized composite flour is not white which can prove to be a limitation in its industrial use. Further studies on overcoming the drawbacks of composite flours are required to establish their specific industrial uses.

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