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Study on storage of physicochemical properties of sweet potato and flaxseed flour

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Abstract
The storage stability of sweet potato (*Ipomoea batatas*) and flaxseed flours was investigated. Sweet potato and flaxseed were processed into sweet potato and flaxseed flours of initial moisture contents of 6.43%, and 4.30% respectively. The processed flours were packaged in glass jar and stored at ambient condition. Physicochemical analysis of the flour samples were carried out at 30 days of interval for a period of 90 days. Subject to the results of the physicochemical analysis of the sweet potato flour and flaxseed flour would be recommended for the production of food samples by food industries either alone or in combination with some other flours for good quality attributes and longer shelf life.

Keywords: Storage stability, sweet potato, flaxseed, flour, shelf life

Introduction
Ipomoea batatas (L) Lam, commonly known as sweet potato belonging to the family Convolvulaceae, is an important root vegetable which is large, starchy, and sweet tasting (Purseglove 1972: Woolfe 1992) [24, 30]. *I. batatas* is grown as an annual plant by vegetative propagation using either storage roots or stem cuttings. The stem is cylindrical and its length depends on the growth habit of the cultivar and the availability of water in the soil. The leaves are simple and spirally arranged alternatively on the stem. Their color can be green, yellowish-green, or can have purple pigmentation in part or all of the leaf blades. The storage roots are the commercial part of the sweet potato plant (Huaman 1992) [8]. The color of the smooth skin of the root tuber ranges between yellow, orange, red, brown, purple, and beige. Its flesh ranges from beige to white, red, pink, violet, yellow, orange, and purple. Sweet potato varieties with white or pale yellow flesh are less sweet and moist than those with red, pink, or orange flesh (Loebenstein and Thottappilly (2009) [16].

Sweet potato has nutritional advantage for the rural and urban dwellers and high in nutritional value (Ingabire and Hilda, 2011) [11]. It provides over 90% of nutrients per calorie required for most people (Food and Nutrition Board 1980: Watt and Merrill 1975) [5, 29]. Sweet potato is an excellent source of energy (438 kJ/100 g edible portion) and can produce more edible energy per hectare per day than cereals, such as wheat and rice (Abu *et al.*, 2000) [31] and has other advantages, such as versatility, high yield, hardiness, and wide ecological adaptability (Laurie *et al.*, 2012) [15].

Sweet potato roots are also rich in starch, sugar, vitamin C, β-carotene, iron, and several other minerals (Laurie *et al.*, 2012; Oloo *et al.*, 2014) [15, 20]. Despite its high carbohydrate content, sweet potato has a low glycemic index due to low digestibility of the starch making it suitable for diabetic or overweighed people (Ellong *et al.*, 2014; Fetuga *et al.*, 2014; ILSI, 2008; Ooi and Loke, 2013) [3,]. The root is reported to usually have higher protein content than other roots and tubers, such as cassava and yams (Oloo *et al.*, 2014) [21].

The incorporation of sweet potato in food products like buns, chapattis, and other bakery products increased total carotenoids contents (Hagenimana *et al.*, 1992) [6] and also sweet potato flour can serve as a source of energy and nutrients (carbohydrates, beta-carotene (pro vitamin A), minerals (Ca, P, Fe, and K)), and can add natural sweetness, color, flavor and dietary fiber to processed food products (Woolfe, 1992; Ulm, 1 988) [30].

Flaxseed belongs to the family *Linaceae* and is an economically important multipurpose oilseed crop that yields ample amount of tiny smooth and flat seeds with a hard shiny shell that is light to reddish brown in color. The seeds possess wide range of health benefits due to the presence of omega-3 fatty acid especially alpha-linolenic acid, which prevents heart disease, inflammatory bowel disease, arthritis etc. and are thus consumed in whole, milled, and oil form. The seeds have been consumed from ancient times for its medicinal purposes to relieve abdominal pains and also as energy source (Oplinger, Oelke, Doll, Brundy, & Schuler, 1989) [23]. The oil percentage in Flaxseed is in the range of 28–42% depending on the variety and cultivation condition (Khan and Saini 2016) [13].

Flaxseed has been identified as a functional food, whose benefits to health are generally attributed to high concentration of lignins and linolenic acid (omega-3) lignins. The improvement in a range of functional properties may be achieved either by genetic modification, chemical processing or physical treatment of the proteins. The functional properties of different proteins can be employed to figure out the fact that how flour proteins can be used to supplement, fortify, enrich or replace more expensive protein source which are used traditionally. Flaxseed is one of those healthy ingredients that is easy to sneak into foods such as cookies, increasing the nutritional value. The advantage of flaxseed proteins compared to other vegetable proteins arises from their association with the mucilage, a co-product in flaxseed, which may enhance their proper-ties in food formulation (Lalmuanpuia *et al.,* (2017) [14].

Materials and Methods

Procurement of Raw Material

Experiments were conducted to study the development of flours from sweet potato and flaxseed and its quality evaluation during storage were conducted in the Food Analysis Laboratory and (PG) laboratory in Department of Agricultural Engineering, College of Post-Harvest and Technology, S.V.P. University of Agriculture & Technology, Meerut. For the flours fresh sweet potato free from insects and diseases and flaxseed were procured from the local market of Meerut, Uttar Pradesh and brought to the laboratory of S.V.P. Meerut for preparation of ready to serve drinks.

Preparation of Sweet potato and Flaxseed Flour

Fresh sweet potato and flaxseed were procured from the local market in meerut and sweet potato were washed into the fresh water to remove the dust and dirt particles, peeling and slicing was done manually. The sliced sweet potatoes were blanched in hot water for 2-3 min and then dried at 60°C for 8-9 hours in a tray drier and milled to pass through a 100µm mesh sieve. Flaxseeds after cleaning all the impurities were roasted in a griddle for 180°C for 10min. After roasting, the seeds were allowed to cool at room temperature. After cooling (30 min), roasted samples were immediately ground into flour by using laboratory grinder at low speed. The flour was packaged in airtight glass jar and stored at room temperature until needed.

Experimental Analysis

Physico-chemical analysis

Physico-chemical properties of flours were determined at the time of 0 day and during storage of 30, 60 and 90 days. The prepared flours were analyzed initially for the parameters of moisture, ash content, protein, fat, fibre, Titrable acidity, pH, Optical density and carbohydrate using following methods. Moisture content of sample was determined by standard air oven method (Ranganna, 2001) [25]. The ash content was estimated by (Ranganna, 2001) [25]. The protein was estimated by micro Kjeldahl Method (AOAC, 1990) [2]. Fat content of flours was determined by (Nagi *et al.*, 2007) [19]. Crude fiber was estimated by employing standard method of analysis (AOAC, 1990) [2]. The samples of flours were mixed with equal quantity of distilled water and the pH was determined using digital pH meter after calibration with standard buffers of 4 and 7 (Ranganna, 2010) [26]. The acidity and the optical density in each sample were determined according to standard procedure given in AOAC (2002). Carbohydrate content of the flour samples was determined by using the formula described by James, 1995.

Statistical analysis

All the experimental analysis was carried out in triplicates. Data were reported as mean and standard deviation. One way ANOVA by Duncan's Multiple Range Test (DMRT) test at 0.05% significant level was carried out to analyze any significant difference during storage. Data analysis was done using SPSS version 20.0.

Results and Discussion

Physico-chemical Properties of Flours

Table 1 and Table 2 shows the effect of storage on physico-chemical properties (moisture content, ash, pH, acidity, protein, fat, fiber, optical density and carbohydrates) of sweet potato and flaxseed flour was analyzed at the time of 0 day and during storage of 30, 60 and 90 days. According to DMRT, storage had significant ($p<0.05$) effect on physico-chemical properties of both the flours. From the data this was observed that the moisture content for sweet potato and flaxseed flour at 0 day was observed as 6.43% and 4.30% respectively. The moisture content for sweet potato flour varied from 6.43% to 7.05% and for flaxseed flour it varied from 4.30% to 4.72% during storage. The moisture contents of both the flours increased with storage period. From the result it was observed that increase in moisture content of both the flour during storage period due to hygroscopic nature of the flour to absorb moisture from the surrounding environment though the packaging material (Singham *et al.,* 2014) [27]. The increases in moisture content during storage correlate the findings of (Adegunwa *et al.,* 2011: Harke *et al.,* 2022: Singham *et al.*, 2014) [1, 7, 27].

The ash content for sweet potato and flaxseed flour at 0 day was observed as 1.52% and 4.03% respectively. The ash content for sweet potato flour varied from 1.52% to 1.49% and for flaxseed flour it varied from 4.03% to 3.85% during storage. The ash content of both the flours decreased with storage period. From the result it is explicit that during storage, ash content tends to decrease in both the flours. Ash content of the flours is also affected due to inorganic mineral content, atmospheric condition and moisture of the flour.

The pH for sweet potato and flaxseed flour at 0 day was observed as 7.26 and 7.84 respectively. The pH for sweet potato flour varied from 7.26 to 6.37 and for flaxseed flour it varied from 7.84 to 7.21 during storage. The pH of both the flours decreased with storage period. From the result it is explicit that during storage, pH tends to decrease in both the flours.

The acidity for sweet potato and flaxseed flour at 0 day was observed as 0.031 and 0.013 respectively. The acidity for sweet potato flour varied from 0.031 to 0.065 and for flaxseed flour it varied from 0.013 to 0.049 during storage. The acidity of both the flours increased with storage period. From the result it is explicit that during storage, acidity tends to increase in both the flours. Similar results were also observed by Harke *et al.*, 2022 [7].

The protein content for sweet potato and flaxseed flour at 0 day was observed as 2.46% and 20.80% respectively. The protein content for sweet potato flour varied from 2.46% to 2.16% and for flaxseed flour it varied from 20.80% to 20.53% during storage. The protein content of both the flours decreased with storage period. From the result it is explicit that during storage, protein content tends to decrease in both the flours. Reduction in protein content during processing may be result of the amino acids which took place during blanching (Mutiara *et al.*, 2013: Indriasari *et al.*, 2016) [18, 10].

The fat content for sweet potato and flaxseed flour at 0 day was observed as 0.67% and 43.05% respectively. The fat content for sweet potato flour varied from 0.67% to 0.53% and for flaxseed flour it varied from 43.05% to 42.86% during storage. The fat content of both the flours decreased with storage period. From the result it is explicit that during storage, fat content tends to decrease in both the flours. Similar results were also observed by (Singham *et al.*, 2014) [27] in which Fat content of both the flours decreased during storage period with increase in moisture, while no change was observed in flavour of the flour i.e oxidative rancidity was not triggered.

The fibre content for sweet potato and flaxseed flour at 0 day was observed as 5.22% and 10.04% respectively. The crude fibre content for sweet potato flour varied from 5.22% to 4.95% and for flaxseed flour it varied from 10.04% to 9.77% during storage. The crude fibre content of both the flours decreased with storage period. From the result it is explicit that during storage, crude fibre content tends to decrease in both the flours. Fibre content decreases during storage period of both the flour may be due to heat treatment which lead to breakage of weak bonds between polysaccharide chains.

The optical density for sweet potato and flaxseed flour at 0 day was observed as 0.295 and 0.234 respectively. The optical density for sweet potato flour varied from 0.295 to 0.298 and for flaxseed flour it varied from 0.234 to 0.235 during storage. The optical density of both the flours increased with storage period. From the result it is explicit that during storage, optical density tends to increase in both the flours.

The carbohydrate for sweet potato and flaxseed flour at 0 day was observed as 80.28 and 29.01 respectively. The carbohydrates for sweet potato flour varied from 80.28 to 79.54 and for flaxseed flour it varied from 29.01 to 28.61 during storage. The carbohydrate of both the flours decreased with storage period. From the result it is explicit that during storage, carbohydrate tends to decrease in both the flours.

Table 1: Effect of Storage on different physicochemical properties of sweet potato flour

Parameters	Storage (Mean ± SEm)					F value
	0 day	30 days	60 days	90 days	Overall	
	N=3	N=3	N=3	N=3	N=12	
Moisture	6.43^{a} ±0.120	6.73^{b} ±0.009	6.87^{bc} ±0.012	7.05^{c} ±0.023	6.77±0.073	17.627**
Ash	1.52^{b}±0.003	1.54^{b} ±0.006	1.50^{a} ±0.003	1.49^{a} ±0.009	1.51±0.007	16.222**
Ph	7.26^{d} ±0.015	7.05^{c} ±0.020	6.82^{b} ±0.017	6.37^{a} ±0.015	6.88±0.101	522.389**
Acidity	0.031^{a} ±0.0006	0.041^{b} ±0.0006	0.056^{c} ±0.0019	0.065^{d} ±0.0009	0.048±0.0041	197.417**
Optical density	0.295^{a} ±0.0003	0.296^{a} ±0.0006	0.297^{a} ±0.0009	0.298^{a} ±0.0017	0.297 ±0.0005	1.213 **
Protein	2.46^{d} ±0.006	2.34^{c} ±0.009	2.24^{b} ±0.015	2.16^{a} ±0.020	2.30±0.034	89.806**
Fat	0.67^{c} ±0.012	0.62^{b} ±0.006	0.56^{a} ±0.012	0.53^{a} ±0.019	0.59±0.017	22.463**
Fibre	5.22^{d} ±0.009	5.15^{c} ±0.009	5.04^{b} ±0.017	4.95^{a} ±0.023	5.09±0.031	55.745**
Carbohydrate	80.28^{d} ±0.013	80.02^{c} ±0.015	79.76^{b} ±0.020	79.54^{a} ±0.013	79.90±0.084	415.116**

*Significant ($p \leq 0.05$), **highly significant ($P<0.01$), Treatment along the columns with different superscripts (a - f) differed significantly at ($p \leq 0.05$)

Table 2: Effect of storage on different physicochemical properties of flaxseed flour

Parameters	Storage (Mean ± SEm)					F value
	0 day	30 days	60 days	90 days	Overall	
	N=3	N=3	N=3	N=3	N=12	
Moisture	4.30^{a} ±0.100	4.59^{b} ±0.003	4.67^{b} ±0.006	4.72^{b} ±0.019	4.57±0.054	13.693**
Ash	4.03^{c} ±0.022	3.93^{b} ±0.015	3.92^{b} ±0.015	3.85^{a} ±0.006	3.93±0.020	21.591**
Ph	7.84^{d} ±0.007	7.66^{c} ±0.023	7.43^{b} ±0.024	7.21^{a} ±0.006	7.54±0.072	252.750**
Acidity	0.013^{d} ±0.0021	0.026^{c} ±0.0017	0.038^{b} ±0.0012	0.049^{a} ±0.0003	0.031±0.0041	112.662**
Optical density	0.234^{a} ±0.0024	0.234^{a} ±00	0.234^{a} ±0.0006	0.235^{a} ±00	0.234±0.0005	0.145**
Protein	20.80^{a} ±0.088	20.72^{a} ±0.012	20.60^{a} ±0.265	20.53^{b} ±0.012	20.61±0.066	0.589**
Fat	43.05^{c} ±0.026	42.95^{b} ±0.007	42.93^{b} ±0.020	42.86^{a} ±0.012	42.95±0.021	18.164**
Fibre	10.04^{d} ±0.012	9.94^{c} ±0.027	9.85^{b} ±0.019	9.77^{a} ±0.009	9.90±0.031	41.946**
Carbohydrate	29.01^{d} ±00	28.87^{c} ±0.018	28.66^{b} ±0.017	28.61^{a} ±0.010	28.79±0.049	204.188**

*Significant ($p \leq 0.05$), **highly significant ($p<0.01$), Treatment along the columns with different superscripts (a - f) differed significantly at ($p \leq 0.05$)

Conclusion

Sweet potato and flaxseed flour is becoming increasingly important and food producers, marketers and consumers are drawing attention to it. In fact, both the flours can generate high income for the farmers because of high market value and profitability. The information presented here shows that both flours have great potential for the production of numerous food products Subject to the results observed in the Physico chemical analysis of sweet potato and flaxseed flours stored the carbohydrate content of both flours decreased with increase in storage duration. Under ambient condition for a period of 90 days, it can be concluded that both flours showed good nutritional stability during the period of storage. Sweet potato and flaxseed flours should be used for the production of different food sample by food industries either alone or in combination with other flours for good quality attributes and longer shelf life.

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