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PROXIMATE COMPOSITION AND FUNCTIONAL PROPERTIES OF IMPROVED ORANGE-FLESHED SWEETPOTATO BREEDING LINES DEVELOPED IN UMUDIKE, ABIA STATE

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ABSTRACT
Sweetpotato [Ipomoea batatas (L.) Lam.] productivity is dependent on the development of improved varieties which have desirable food quality attributes. Proximate and functional properties of twelve newly developed orange-fleshed sweetpotato breeding lines namely: F1M1/16 (UMUSPO/3 X TIS8164/16), F1MI/23 (UMUSPO/3 X TIS8164/23), F1M1/24 (UMUSPO/3 X TIS8164/24), F1M1/25 (UMUSPO/3 X TIS8164/25), F1M1/26 (UMUSPO/3 X TIS8164/26), F1M1/32 (UMUSPO/3 X TIS8164/32), F1M1/33 (UMUSPO/3 X TIS8164/33), F1M1/36 (UMUSPO/3 X TIS8164/36), F1M1/83 (UMUSPO/3 X TIS8164/83), F1M1/86 (UMUSPO/3 X TIS8164/86), F1M1/88 (UMUSPO/3 X TIS8164/88) and F1M1/91 (UMUSPO/3 X TIS8164/91) were investigated. Results obtained showed that the sweetpotato lines were high in dry matter (27.30 to 41.34%) and starch (16.38-27.66%) contents. The crude protein, fiber and ash contents varied significantly ($p<0.05$) among the genotypes. The sweetpotato flours had high bulk densities ranging from 0.92g/cm3 (in FIM1/26) to 1.27g/cm3 (in FIM1/24) suggesting their suitability as thickeners. The water absorption capacity of the flours from the sweetpotato lines which ranged from 1.57 (in FIMI/36) to 2.01ml/g (in FIM1/88) is an indication of their suitability in the bakery industry. The sweetpotato lines have potentials for both domestic and industrial applications.

Keywords: sweetpotato, breeding lines and functional properties

Introduction

Sweetpotato ranks the fifth most important food crop on a fresh weight basis in developing countries after rice, wheat, maize, and cassava and it is cultivated in over 100 developing countries under tropical and sub-tropical climates (Aina *et al.*, 2012, Away *et al*, 2013). World production has been estimated at 110 million tonnes per annum (FAOSTAT, 2009). China with a production of 85.2 million tonnes represents 77% of the world sweetpotato production (FAOSTAT, 2009). However, in sub-Saharan Africa, sweetpotato production is 13.7 million per annum representing 12.4% of the world production. Sweetpotato is an excellent source of vitamin A and C, high in energy and dietary fiber with 6.9 to 30.7% starch (Tian *et al*, 1991). Sweetpotato is especially valuable because of its high levels of nutrition, high productivity and low levels of input (Hagenimana and Owori, 1996). In spite of its numerous qualities, it is underexploited and this is probably because of its status as a poor man's food (Woolfe, 1992). In Nigeria, the majority of sweetpotato that is consumed is the white fleshed which has low levels of pro-vitamin A (β-carotene content) (Ameny and Wilson, 1997). There are efforts by Harvest Plus Program to promote the use of orange-fleshed sweetpotato (OFSP) varieties that contain high β-carotene content. According to Afuape (2009, 2013) National Root Crops Research Institute, Umudike has developed some improved varieties of OFSPs with good genetic and agronomic characteristics which have been released to farmers. Attempts are being made to develop new OFSP varieties that contain high dry matter and disease resistance. Sweetpotato is processed into noodles, starch, chips in China but in Nigeria, it is mostly consumed in boiled, fried or roasted form owing to the low level of processing and storage facilities (Oluwaseyi *et al.*, 2012). The functional properties of the sweetpotato give an insight into the diverse potential applications of the crop for domestic and industrial purposes (Kim *et al*., 2013). Most times, variation in physico-chemical properties of different sweetpotato genotypes can be traced to the crop's genetic characteristics. Although significant varietal differences have been documented in sweetpotato physicochemical properties (Tsakama *et al.*, 2010; Nandutu *et al.*, 2000), no previous investigations on the physicochemical composition of these sweetpotato breeding lines have been made. There is therefore, the need to assess the nutritional and the functional properties of these breeding lines. The result from these studies would stimulate both their industrial and domestic applications. This work is aimed at evaluating the physiochemical properties of some selected orange- fleshed sweetpotato breeding lines for their industrial suitability.

Materials and Methods

Twelve breeding lines of mature orange- fleshed sweet potato roots namely: F1M1/16, F1MI/23, F11M/24, F1M1/25, F1M1/26, F1M1/32, F1M1/33, F1M1/36, F1M1/83, F1M1/86, F1M1/88 and F1M1/91 developed by the Sweetpotato Breeding Program of the National Root Crops Research Institute, Umudike, were used for this study. Their characteristics are shown in Table 1. The sweetpotato lines were harvested at four months after planting. Samples were collected at harvest and used for evaluation of moisture content according to AOAC (2000) and starch yield using the method described by Perez *et al*. (2011). The other samples were peeled, chipped, oven dried at 60^{0}C, ground and used for analysis of proximate composition and functional properties. The proximate composition of the sweetpotato lines: ash, crude protein, fat, fibre and carbohydrate contents were estimated according to the standard methods of AOAC (2000). The water and oil absorption capacity, foaming capacity (FC) and foam stability (FS) were determined using the method of Sathe *et al*., (1981). Bulk density was determined by the method of Narayana and Narasinga (2006) and the swelling index was determined using the method of Lin *et al***.** (1974).

Table 1: Characteristics of the orange-fleshed sweetpotato lines evaluated.

Genotype	Pedigree	Status	Flesh colour
F1M1/16	UMUSPO/3 X TIS8164/16	Breeding lines	Orange
F1MI/23	UMUSPO/3 X TIS8164/23	Breeding lines	Orange
F11M/24	UMUSPO/3 X TIS8164/24	Breeding lines	Orange
F1M1/25	UMUSPO/3 X TIS8164/25	Breeding lines	Orange
F1M1/26	UMUSPO/3 X TIS8164/26	Breeding lines	Orange
F1M1/32	UMUSPO/3 X TIS8164/32	Breeding lines	Orange
F1M1/33	UMUSPO/3 X TIS8164/33	Breeding lines	Orange
F1M1/36	UMUSPO/3 X TIS8164/36	Breeding lines	Orange
F1M1/83	UMUSPO/3 X TIS8164/83	Breeding lines	Orange
F1M1/86	UMUSPO/3 X TIS8164/86	Breeding lines	Orange
F1M1/88	UMUSPO/3 X TIS8164/88	Breeding lines	Orange
F1M1/91	UMUSPO/3 X TIS8164/91	Breeding lines	Orange

Statistical Analysis

The data obtained were subjected to one-way Analysis of Variance using Statistical Package for Social Science (SPSS) Version 20.0 software. Mean values were separated by the Least Significant Difference (LSD) test.

Results and Discussion

Table 2 shows the proximate composition of the sweetpotato breeding lines. The moisture content of the breeding lines ranged from 58.44% (in FIMI/33) to 72.71% (in FIMI/83) and they were significantly different ($p<0.05$) from one another. The values are similar to the values obtained by Rodrigues (1995) which ranged from 69.4 % - 73%. High moisture content of the roots is an indication that they will be susceptible to spoilage if stored fresh. The high moisture content of the roots makes them more desirable for boiling and baking (Aina, 2012). The ash content of the sweetpotato lines ranged from 1.95% (FM1/91) to 2.68% (FM1/24) and varied significantly ($p<0.05$) among the breeding lines. A similar result (average of 2.31%) was reported by Dincer *et al*., (2011) for three sweetpotato cultivars from Turkey. Ash content represents the mineral contents of a food material - calcium, phosphorus, magnesium, sodium, potassium, iron, zinc and copper, and are the main mineral constituents in sweetpotato roots (Bouwkamp, 1985). Minerals such as iron, copper, zinc and manganese play important roles in the biological system (Junsei, *et al*., 2013).

The crude fibre content of the sweetpotato lines ranged from 2.86% (in FM1/24) to 3.61% (in FIM1/36) and was significantly different among the lines. The crude fiber is higher than the values (1.81-3.00%) obtained by Sanouss *et al*., 2016 in Benin, but in line with the work of Rodrigues (1995) who reported the value of crude fiber to be 3.68- 2.76%. The high crude fiber content is an indication of the diseases (colon cancer, cardiovascular diseases) management potential The crude protein content of the evaluated sweetpotato lines ranged between 2.62% (in FM1/86 and FIM1/32) to 3.00% (in FIM1/26). The recommended daily allowance of proteins for an infant is 9.1-13.5 g/day, children (13-19 g/day), adult women (34-46 g/day) and adult men (45 - 50 g/day) (Dashak *et al*., 2001). The low protein content of sweetpotatoes can hardly supply the recommended daily allowance of proteins**,** and therefore, food products from sweetpotato need to be supplemented with protein rich foods.

The starch content of the samples ranged from 16.38% (in FM1/83) to 27. 66% (in FIM1/25) with the starch contents significantly different ($p<0.05$) among the lines. The result obtained is in line with the work of Aina *et al.*, (2012) who reported sweetpotato starch between 6.9 to 30.7% and Kohyama and Nishinari (1992) who obtained values ranging from13.4 to 29.2% of starch in different sweetpotato roots. On the other hand, Warombi *et al*., (2011) reported the starch content of 30-58% for twenty-five sweetpotato varieties from Papua New Guinea and Australia. According to Warombi *et al*., (2011), the starch content is directly related to genotype and environmental conditions in which the plant is cultivated. In sweetpotato roots, starch is the main component, followed by simple sugars. In food industries, starch is added to enhance functional properties of soups, meat sauces etc. The starch content affects the swelling power since an increase in total starch leads to an increase in swelling power (Rampersad *et al*., 2003).

The dry matter content ranged from 27.30% to 41.34%, which is significantly different ($p>0.05$) for all the samples. This is higher than the values gotten by Laurie *et al*., (2013) who reported dry matter content of some OFSPs as 19.4- 22.6%, but similar to the value reported by Sanouss *et al*.,2016 in Benin of 25.09 to 46.12 %.. The dry matter of sweetpotato roots is an important character for the acceptance of the roots by researchers, processors and consumers. The sweetpotato lines studied have high dry matter contents with FIM1/33 having the highest dry matter content while FIM1/83 and FIMI/32 had the lowest dry matter content. According to Eleazu and Ironua (2015), high dry matter content contribute to better storability, good texture, product yield, and therefore it has the potentials of been used for industrial purposes and for flour production in confectioneries. Dry matter content is influenced by several factors such as the age of the plant, crop season, location, variety and efficiency of the crop to trap sunlight.

Functional properties

Functional properties of flour are important for the selection of crops for use in value-added product development. The functional properties of the flours from the sweetpotato breeding lines are shown in Figures 1- 6. Water absorption property indicates the ability of a product to associate with water under conditions when water is limiting such as making of dough and paste. The water absorption capacity (WAC) of the samples ranged from 1.57 (in FIMI/36) to 2.01ml/g (in FIM1/ 88) (Figure 1). This shows that FIM1/36 had the ability to absorb more water during processing into dough. The ability to absorb water is a very important property of all starches used in food preparations. The high values of WAC can be attributed to the amount and nature of hydrophilic constituent and nature of the protein. The result of this study suggests that the flours from this OFSP breeding lines would be useful in foods such as bakery products which require hydration to improve handling characteristics.

The oil absorption capacity of the sweetpotato breeding lines (Figure 2) ranged from 1.10 (in FIM1/32) to 1.40ml/g (in FIM1/83). The oil absorption capacity of flours is important for the development of new food products as well as their storage stability (particularly for flavor binding and in the development of oxidative rancidity). Both the protein content and the type contribute to the oil-retaining properties of food materials (Ravi and Sushelamma, 2005). Oil absorption capacity is attributed mainly to the physical entrapment of oils. It is an indication of the rate at which protein binds to fat in food formulations (Onimawo and Akubor, 2012). The swelling index of the sweet potato flours ranged from 2.4% (in FIM1/16 and FIM1/91) to 3.1% (in FIM1/36). Swelling power of flour granules is an indication of the extent of associative forces within the granule (Moorthy and Ramanujam, 1986). It depends on sizes of particles, types of variety and processing methods.

The bulk density ranged from 0.92 to 1.27g/cm^3 and there was a significant difference among all the samples with sample FIMI/27 having the highest value. The bulk density observed in this study is higher than the 0.68 – 0.82 g/cm^3 range reported by Etudaiye *et al*., (2014). Bulk density is a measurement of the porosity of a product which influences the design of the packaging material. Bulk density is affected by the moisture content and the particle sizes of the starch. The differences in the particle size may be the cause of variations in bulk density of the orange-fleshed sweetpotato. The high bulk density of the sweetpotato breeding lines is an indication that they can be used as thickeners (Adebowale *et al.*, 2009).

Foam capacity refers to the amount of interfacial area that can be created by the protein (Fennema, 1996). Foam is a colloidal of many gas bubbles trapped in a liquid or solid, it is used to detect texture, consistency and appearance. Foam capacity of a food material varies with the type of native protein, solubility and other factors (Eze and Akubor, 2012). Sample FIM1/36 had the highest foam capacity (19.6%) while FIM1/24 had the lowest (14.6%). Foam stability refers to the ability of protein to stabilize against gravitational and mechanical stresses (Fennema, 1996). Foam stability is important since the usefulness of whipping agents depend on their abilities to maintain the whip as long as possible. Line FIM1/83 had the highest foam stability while FIMI/25 had the lowest. Line FIMI/36 which had the highest foam capacity has low foam stability while FIMI/24 which had the lowest foam capacity had high foam stability. Line FIMI/83 which has both high foam capacity and foam stability can serve as a good whipping agent.

Table 2: Proximate composition of orange-fleshed sweetpotato lines

Samples	Moisture (%)	Ash (%)	Crude Fibre (%)	Crude Protein(%)	CHO (%)	Starch (%)	DM (%)
F1M1/16	66.90^{c}	1.99^{gh}	3.20^{f}	2.70^{cb}	24.05^{f}	18.34^{e}	33.10^{g}
F1M1/23	64.64^{f}	2.20^{e}	2.98^{j}	2.84^{cb}	26.27^{b}	25.60^{b}	35.36^{e}
F1M1/24	63.97^{g}	2.68^{a}	2.86^{k}	2.78^{cb}	26.18^{d}	23.37^{c}	36.03^{d}
F1M1/25	60.30^{i}	2.02^{g}	3.01^{i}	2.73^{cb}	30.99^{b}	27.66^{a}	39.70^{b}
F1M1/26	62.90^{h}	2.13f	2.96^{j}	3.00^{ab}	27.59^{c}	24.04^{c}	37.10^{c}
F1M1/32	72.45^{a}	2.14^{f}	3.52^{b}	2.62^{cb}	18.36^{h}	16.71^{hg}	27.55^{j}
F1M1/33	58.44^{j}	2.31^{d}	3.19^{s}	3.50^{a}	32.00^{a}	23.63^{c}	41.56^{a}
F1M1/36	63.30^{f}	2.02^{g}	3.61^{a}	2.65^{bc}	25.44^{e}	17.40^{fg}	34.70^{f}
F1M1/83	72.70^{a}	2.49^{c}	3.33^{d}	2.56^{cb}	17.96^{i}	16.38^{h}	27.30^{j}
F1M1/86	67.78^{b}	2.62^{b}	3.48^{c}	2.62^{cb}	22.30^{g}	17.50^{f}	32.22^{i}
F1M1/88	63.10^{ef}	2.28^{d}	3.31^{e}	2.87^{ab}	23.19^{e}	19.57^{d}	34.90^{ef}
F1M1/91	66.29^{d}	1.95^{h}	3.12^{h}	2.63^{bc}	25.12^{e}	20.13^{d}	33.71^{g}
LSD	0.609	0.041	0.026	0.492	0.614	0.783	0.605

Means down the column with the same superscript are not significantly different at p>0.05

Functional properties

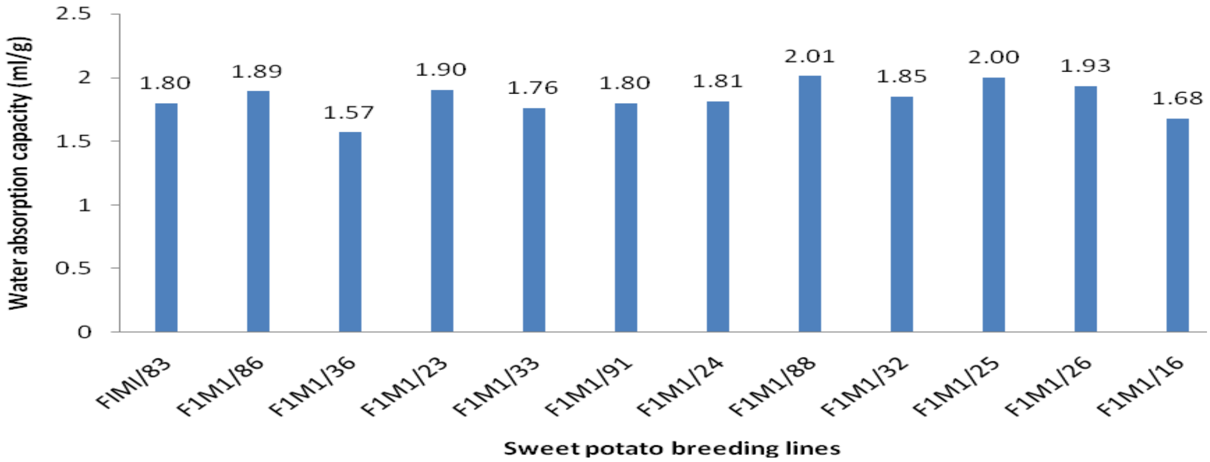

Figure 1: Water absorption capacity of the 12 sweetpotato breeding lines evaluated for their functional properties

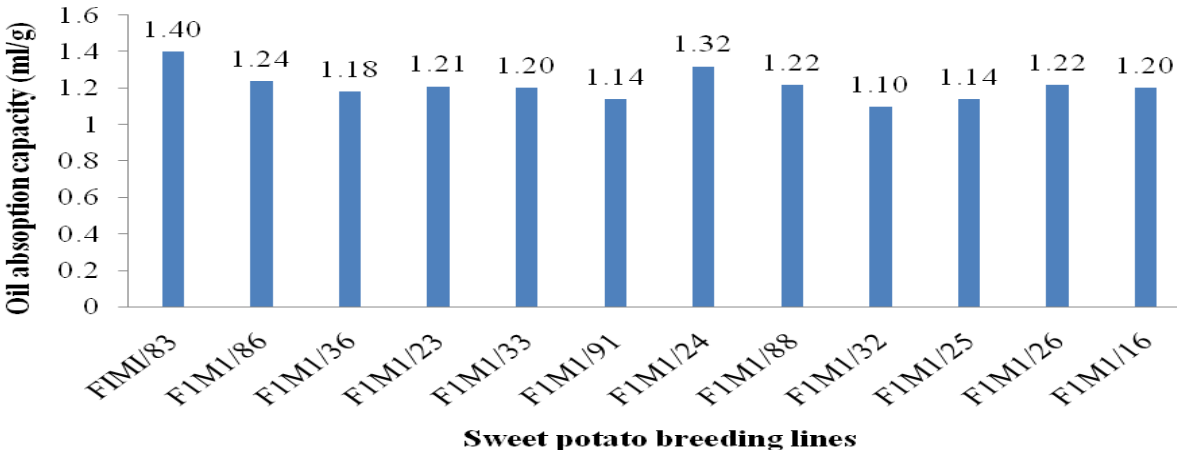

Figure 2: Oil absorption capacity of the 12 sweetpotato breeding lines evaluated for their functional properties

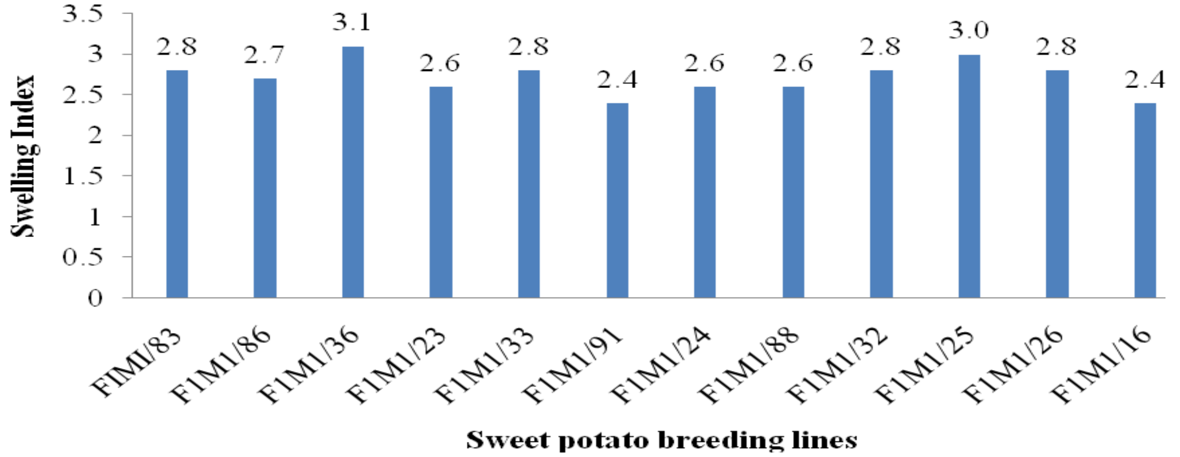

Figure 3: Swelling index of 12 sweetpotato breeding lines evaluated for their functional properties

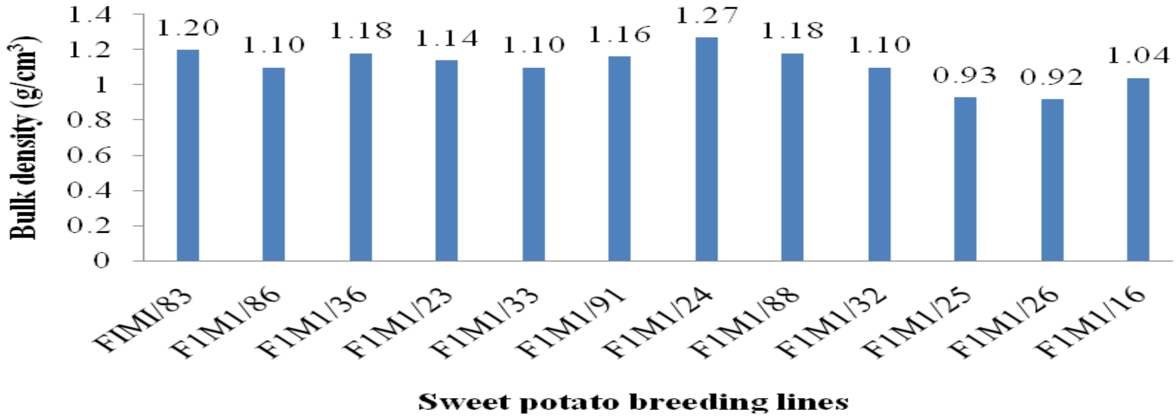

Figure 4: Bulk density of 12 sweet potato breeding lines evaluated for their functional properties

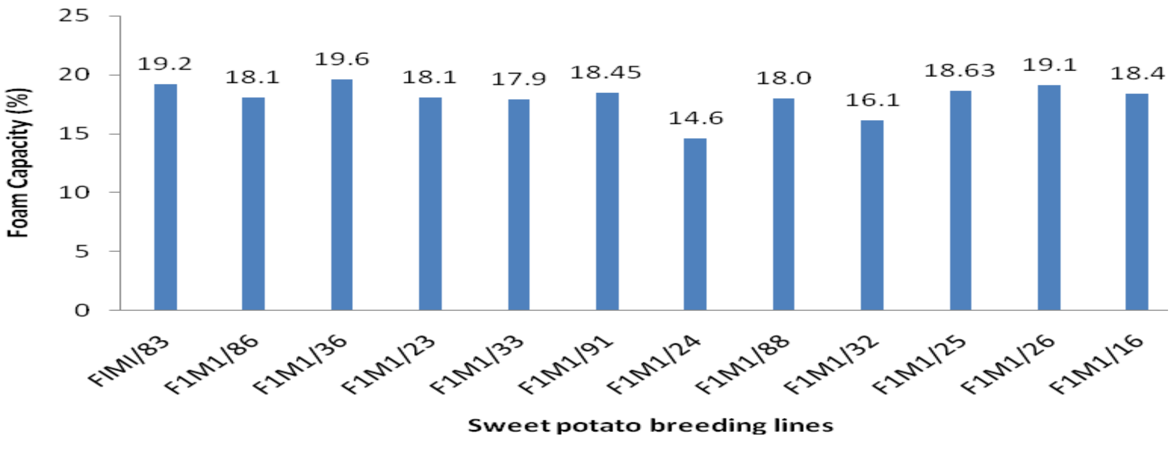

Figure 5: Foam capacity of 12 sweetpotato breeding lines evaluated for their functional properties

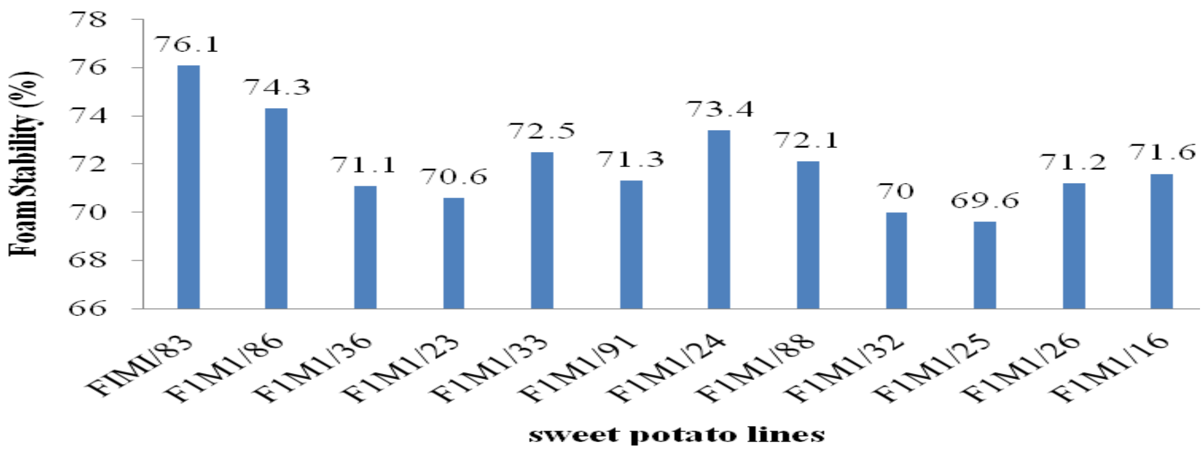

Figure 5: Foam stability of 12 sweetpotato breeding lines evaluated for their functional properties

Conclusion

The result of this study indicated that the different breeding lines combined different proximate composition and functional property attributes. Lines F1M1/25, F1M1/26 and F1M1/36 combined high starch yield and dry matter, good bulk density, and oil and water capacity, swelling index, foam capacity and stability. While other lines also showed good but few properties, lines F1M1/25, F1M1/26 and F1M1/36 will have good industrial application for food formulation. Efforts should be made to promote their cultivation for industrial use. Also, further studies on the pasting properties of the starches from these three outstanding lines should be carried out to enhance their pasting potentials.

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