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Evaluation of selected Kenyan potato cultivars for processing into French fries

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Potato processing, physical characteristics, frozen chips, sensory properties

1 SUMMARY

The demand for potato varieties (*Solanum tuberosum* L.) with acceptable yield and processing characteristics is increasing in Kenya. However, most potato varieties and promising clones have not been adequately evaluated. In this study, three advanced potato clones (393385.47, 393385.39 and 391691.96) and five established Kenyan varieties (Tigoni, Desiree, Dutch Robyjn, Kenya Karibu and Kenya Sifa) were evaluated for processing into fresh and frozen French fries. All the 8 cultivars had acceptable physical tuber characteristics, dry matter content (≥ 20 %) and specific gravity (≥ 1.070). A linear positive correlation was established between tuber specific gravity and dry matter content (r= 0.97). All the cultivars made highly acceptable French fries (freshly prepared or frozen), with clones 393385.47 and 393385.39 having lower acceptability scores. The five varieties (Tigoni, Desiree, Dutch Robyjn, Kenya Karibu and Kenya Sifa) and clone 391691.96 can also be used for processing fresh or frozen chips to supplement variety Tigoni that is currently the most preferred for processing in Kenya. This will reduce over reliance on a single potato variety for this rapidly expanding industry, and thus safeguard availability and quality of raw materials.

2 INTRODUCTION

Potato is an important crop in Kenya, with a major role in food and income security and is second only to maize in terms of utilization. Production is mainly confined to the highlands (1500-3000 m above sea level) where the crop has higher yields than most other food crops (MoA, 2005). Many potato varieties including Roslin Eburu, Roslin Tana, Nyayo, Kenya Sifa, Kenya Baraka, Desiree, Asante, Tigoni, Annet, Dutch Robyjn and Kerr's Pink are currently marketed in Kenya (KAIC, 2004). However, most of these varieties are faced with the challenge of susceptibility to diseases and poor processing qualities (MoA, 2007). Although the National Potato Research Center (KARI-Tigoni) continues to develop new varieties that are presumed to be superior to existing ones in terms of disease tolerance (mainly late blight and viruses), the processing qualities of the newer varieties have not been adequately examined.

Information on the processing characteristics of popular varieties and promising potato clones is required in order to support the rapidly expanding potato industry with high quality raw materials. The most

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important products in the Kenyan potato processing industry are fresh potato chips (French fries), followed by crisps and frozen chips. The demand for these products has rapidly increased as evidenced by explosive growth of fast food restaurants and snack bars in the urban areas (Walingo *et al.*, 2004). Several companies are also involved in the production of frozen potato chips in the local market (Kabira, 2002).

The biggest drawback to the expansion of the potato processing industry is the unavailability of adequate stocks of good quality tubers that have high dry matter content, low oil absorption and good sensory properties. Currently, most stocks used for processing are immature potatoes that result into unattractive fried products due to their high levels of reducing sugars. To be sustainable, the processing industry requires potatoes with superior characteristics in high dry matter, good product colour, lower oil absorption and higher yields (Weaver *et al.*, 1975). Variety Tigoni, which is currently mostly used for processing fresh and frozen French fries, greens rapidly on slight exposure to sunlight as is common practice in Kenyan potato production and marketing systems, thereby reducing its storage life. Its resistance to viral diseases is also breaking down (Kabira & Lemaga 2006; CIP 2008).

Development and promotion of potato cultivars with good processing and storability potential could provide a means of preserving surpluses realized during peak production seasons, thereby reducing post-harvest wastage and improving the stakeholders' income. This study examined the suitability in terms of physical characteristics, oil absorption and sensory acceptability of 8 Kenyan potato cultivars for processing into freshly prepared or frozen French fries.

3 MATERIALS AND METHODS

3.1 Potato tuber production: Three promising clones coded 393385.47, 391696.96 and 393385.39 from the International Potato Center (CIP) and five varieties (Tigoni, Desiree, Dutch Robyjn, Kenya Karibu and Kenya Sifa) were grown at the National Potato Research Center Tigoni (2200 m above see level) in the year 2007 under standard cultural conditions (Lung'aho & Kabira, 1999). After maturity, the crop was dehaulmed two weeks before harvesting. After harvesting, the tubers were allowed to cure in the store at ambient air conditions (15-19 ^{o}C/86-92 % RH) for three weeks. The processing and evaluation were carried out in the food science laboratories at the Kenya Agricultural Research Station (KARI) in Tigoni (processing and sensory evaluation), the Jomo Kenyatta University of Agriculture and Technology (laboratory analysis) and at the College of Agriculture and Veterinary Sciences of the University of Nairobi (validation of laboratory results).

3.2 Preparation of French fries: Potato samples (10 tubers per cultivar) were hand-peeled, and cut lengthwise using a hand-operated chip cutter producing 12x12 mm strips in cross-section. Short or broken pieces were removed. The selected strips were washed to remove surface starch and dried before frying using a deep fat fryer (frifri E6 ARO S.A Neuveville, Switzerland) equipped with a thermostatically controlled electric heating coil. The strips were pre-fried at 170 ^{o}C for 2 min (par frying) and finish-fried afterwards at the same temperature for 5 additional minutes. The fries were drained off oil (1 min), placed on plates and left to cool at room temperature before being packaged into polyvinyl chloride bags (gauge 125). The chips in sealed bags were taken to the laboratory for evaluation. For frozen storage, the par-fried chips were packaged into the PVC bags (gauge 125), sealed and stored in a deep freezer at -18 ˚C for three months before finish frying at 170 ˚C for 2 minutes followed by sensory and laboratory evaluation.

3.3 Physical tuber characteristics: The characteristics evaluated were tuber shape, size, skin and flesh colour, and eye depth. These were determined visually and using a hand-held sizer gauge (Talburt & Smith, 1977; Kabira & Lemaga, 2006).

3.4 Analytical methods

3.41 Dry matter content: Five whole tubers were randomly selected from each cultivar and chopped into small cubes (1-2 cm pieces) and mixed thoroughly. Dry matter content was determined by

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drying triplicate 20 g samples at 80 °C for 72 hr in a forced air oven.

3.42 Specific gravity: Specific gravity was determined in the raw tubers according to weight under water method as described by Ludwig (1972) and Kabira and Lemaga (2006).

3.43 Oil content: Chips were finely ground in a blender and 5 g sample was put into a thimble, 16-hr Soxhlet extraction was conducted using analytical grade petroleum ether (boiling point 40-60 °C) as described by Lulai and Orr (1979).

3.44 Sensory evaluation: Coded samples were presented to 10 panellists, all being familiar with French fries. Panel members scored for colour, texture, flavour, oiliness and overall acceptability on a 9-point hedonic scale (Larmond, 1977) ranging from 1 (extremely dislike) to 9 (extremely like). A score of 5 was the lower limit of acceptability. The evaluations were carried out between 10 am and 12.30 p.m. since sensory evaluation requires that samples are analyzed either mid morning or afternoon to avoid influence due to hunger or satisfaction (Larmond, 1977). Analysis of variance was done to compare the difference in chips quality as affected by cultivar.

3.5 Data analysis: Data were subjected to analysis of variance (ANOVA) and means separated by least significant difference test using Statistical Analysis System (SAS version 9). Pearson correlation analysis was also performed to determine linear relationships where necessary.

4 RESULTS AND DISCUSSIONS

4.1 Physical tuber characteristics: physical tuber quality characteristics varied greatly among the cultivars (Table 1) and Figure 1)

Table 1: Physical tuber quality characteristics of 8 Kenyan potato cultivars.

Cultivar	Tuber characteristic						
	Shape	**Diameter[1]**	**Length[2]**	**Eye depth**	**Skin colour**	**Flesh colour**	**Processing suitability[3]**
Tigoni	Round oval	65-75	60-80	Shallow	Cream	Cream	OK
Desiree	Long oval	55-70	80-140	Medium	Red-purple	White	OK
Dutch Robyjn	Round	55-65	55-80	Medium	Red-purple	White-yellow	OK
Kenya Karibu	Round	65-75	70-90	Medium	Deep-Red	Yellow	OK
Kenya Sifa	Flat/round	70-80	70-80	Medium	Pink	Cream	OK
393385.47	Round	60-70	70-80	Shallow	Cream	Yellow	OK
393385.39	Round	55-65	45-60	Medium	Red-purple	White	OK
391692.96	Round	50-65	50-60	Shallow	Dark-purple	Cream/white	OK

[1]Diameter in mm; [2]length in mm; [3]processing into French fries

All the 8 cultivars had acceptable sizes (≥50 mm diameter) and length (≥30 mm) as recommended for French fries (Kabira & Lemaga, 2006), which is appreciated by most consumers (Oreldo, 2004; Walingo *et al.*, 2004). Tuber shape and size are important characteristics with respect to external quality and greatly influence peeling and trimming losses during processing. The potatoes should therefore have good round or oval shape and acceptable in order to limit these losses (Talburt & Smith, 1967; Kabira, 2000). Furthermore, tuber shape and size influences the length of French fries; the tubers preferred by processors are long oval, oblong or elongated to give long-shaped finished products. Variety Desiree with elongated tubers is the best suited for processing into French fries. Varieties Tigoni, Kenya Sifa and clones 393385.47, and 391697.96, that are round or oblong also meet the shape criteria required for processing French fries. Varieties Dutch Robyjn, Kenya Karibu, and clone 393385.39 have round shapes but they all have tuber sizes ≥50 mm diameter, which is in the range required, especially for processing short French fries.

All the cultivars had either shallow or medium eye depths, which is ideal to minimize

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losses during peeling and trimming (Smith, 1975; Kabira & Lemaga, 2006).

Most cultivars had white/cream or red skin colours, except clone 391691.96 which had dark-purple skin, while white/cream flesh colour was dominant. White or red skin colour is associated with good quality by most Kenyan consumers (Kabira, 2000). The clone 391691.96 is an exception as it has dark purple skin colour, which is rare and thus may not be popular with the consumers at the initial stages of introduction, though it may trigger curiosity, and it does not affect process suitability.

Figure 1: Tuber appearances of variety Kenya Karibu and clone 393385.47. Difference can be seen in skin colour.

4.2 Specific gravity, dry matter and oil content: There were significant ($P \leq 0.05$) differences in the dry matter contents of the cultivars (Table 2). The specific gravity of the cultivars varied from 1.075 in clone 393385.39 to 1.092 in variety Dutch Robyjin. With specific gravity of 1.075 and above, all the tubers were suitable for processing French fries (Smith, 1975; Kabira & Lemaga, 2006). Dry matter content ranged from 20.56 % in clone 393385.39 to 24.66 % in Dutch Robyjn. This range of dry matter content falls within recommended levels for French fries processing. Cultivar Dutch Robyjn had consistently high specific gravity followed by clone 393385.47 while clones 393385.39 and 391691.96 had low levels. A linear positive correlation (r= 0.97) was established between tuber specific gravity and dry matter. Such relationship was reported on sweet potatoes (Hagenimana *et al.*, 1998).

High dry matter content was present in all the cultivars with Dutch Robyjn having the highest content followed by cultivar Tigoni. Whereas the results of dry matter content in cv. Dutch Robyjn are lower than reported in an earlier study by Imungi (1987), the levels in variety Desiree were closely comparable.

Table 2: Specific gravity, dry matter and oil content of 8 Kenyan potato cultivars.

Cultivar	Specific gravity[a] ± SD	Dry matter content[b] ± SD	Oil content (% dry weight basis)		
			Raw tubers	Fresh Fries	Frozen fries
393385.39	1.075 ± 0.003	20.556 ± 0.092	0.44 ± 0.170	7.44 ± 0.640	10.85 ± 0.490
393385.47	1.083 ± 0.003	22.836 ± 0.250	0.45 ± 0.060	9.45 ± 0.650	13.45 ± 0.380
391691.96	1.076 ± 0.002	20.973 ± 0.421	0.49 ± 0.180	7.77 ± 0.330	11.77 ± 0.100
Desiree	1.087 ± 0.003	22.213 ± 0.163	0.45 ± 0.020	9.82 ± 0.420	15.33 ± 0.620
Dutch Robyjn	1.092 ± 0.003	24.660 ± 0.178	0.40 ± 0.050	6.40 ± 0.880	10.38 ± 0.100
Kenya Karibu	1.081 ± 0.001	21.136 ± 0.239	0.38 ± 0.100	8.58 ± 0.110	13.00 ± 0.840
Kenya Sifa	1.082 ± 0.002	20.880 ± 0.191	0.53 ± 0.080	9.01 ± 0.020	13.11 ± 0.760
Tigoni	1.084 ± 0.002	22.283 ± 0.375	0.46 ± 0.180	7.61 ± 0.860	11.13 ± 0.850

[a] Determined by the-under water weight method; [b]Determined by oven drying.

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In the raw tubers the oil content ranged from 0.38 to 0.53 %, with the lowest being for cv. Kenya Karibu and the highest for cv. Kenya Sifa. These values compare well to the findings of Gilliard (1973) of 0.4 to 0.65 % (dry weight basis) in 23 potato varieties. Although this oil content is too low to have any nutritional significance, it contributes towards potato palatability, enhances tuber cellular integrity and resistance to bruising, and plays a part in reducing enzymatic darkening in tuber flesh (Woolfe, 1987). Approximately 75 % of fatty acids of the potato lipids are polyunsaturated linoleic and linolenic acids that contribute to production of both desirable flavour characteristics in cooked tubers and undesirable 'off' flavours in processed products.

Frying of potatoes, however, increased oil content significantly ($P \leq 0.05$) ranging from 6.4 % in cv. Dutch Robyjn to 9.82 % in cv. Desiree. Moreover, frozen fries had higher levels of oil content compared to fresh fries. These findings compare well to those of Greenfield *et al*. (1984) and Melton *et al*. (2001). Oil content is a major factor that consumers consider in determining acceptability of the fries, being best when crunchy or rejected when oily and soggy. On the other hand, oil as a major raw material in chips processing may lead to major losses by the processor if the potatoes used absorb too much of it.

Many factors have been reported to affect fat uptake into French fries, including oil quality, frying temperature and duration, product shape, moisture content, solid content, gel strength, and proteins. The potato cultivar, however, remains a major factor of consideration by any processor (Pinthus *et al*., 1995). The potato cultivar had significant ($P \leq 0.05$) effect on fat uptake in the French fries. The different cellular structures may have affected fat uptake by influencing either the loss of moisture or damage done to original anatomy during processing.

4.3 Sensory quality characteristics of French fries: The sensory attributes evaluated differed significantly ($P \leq 0.05$) among the cultivars. Variety Desiree had the highest colour score (6.77) while clone 393385.39 had the least score (5.33) for freshly prepared chips (Table 3). The same trend was also noticed for the texture parameter. Variety Tigoni had the highest score in flavour (6.53) while clone 393385.47 had the lowest (5.61). In oiliness variety Desiree scored poorly (6.00) compared to Tigoni (6.77). It was, however, clone 393385.47 that had the lowest score (5.55) in oiliness. Cultivar Tigoni had the highest score (6.76) while clone 393385.47 had the lowest (5.73) on flavour perception. All the varieties and clones were generally acceptable with varieties Kenya Sifa, and Dutch Robyjn having higher scores while clone 393385.39 had the lowest score.

The attributes significantly ($P \leq 0.05$) differed among the cultivars when the fries were frozen. Variety Desiree scored highly in colour (6.65) compared to clones 393385.39 and 393385.47 that had lowest score (4.77) that is below the acceptable limit. Frozen fries of varieties Kenya Sifa, Dutch Robyjn, Tigoni and Kenya Karibu were closely comparable in colour while Desiree had a highest score. Colour scores for the 3 clones, however, significantly ($P \leq 0.05$) reduced on freezing.

Cultivars Kenya Sifa and Desiree scored highly in texture and oiliness compared to clones 393385.39 and 393385.47 that had the lowest scores. Textural score for clone 393385.39 was below the lower limit (4.66). Freezing did not, however, have significant ($P > 0.05$) effect on the two attributes in the 5 established varieties as opposed to significant ($P \leq 0.05$) reduction in the three clones. Flavour scores were significantly ($P \leq 0.05$) lower in all cultivars especially after frozen storage, but clone 391691.96 had the highest score (5.88) while clone 393385.47 had the least score (5.00). In general, all the varieties and clones made acceptable frozen fries with clone 393385.39 being just acceptable with an overall acceptability score of 5.00 that is the lower limit. Fries from cv. Desiree were highly acceptable followed by Kenya Sifa, Dutch Robyjn, Tigoni, Kenya Karibu, clone 391691.96 and clone 393385.47.

Based on the findings of this study, it is concluded that clone 391691.96 compared well to the more established varieties while clones 393385.39 and 393385.47 were also less acceptable. The study established that all the 8 selected Kenyan potato cultivars are suitable for processing into fresh or frozen French fries. Therefore, where the varieties meet other agronomic requirements and selection criteria, the seed multiplication program at the National Potato Research Centre (KARI) should ensure adequate production and distribution of these cultivars to farmers. The varieties should also be promoted for commercial use by the potato industry.

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Table 3: Sensory quality characteristics for freshly prepared and frozen French fries from 8 Kenyan potato cultivars.

Cultivar	Treatment	Colour	Texture	Oiliness	Flavour	Overall acceptability
Desiree	Fresh	6.77a	6.60a	6bcd	5.80b	6.46a
	Frozen	6.65a	6.44a	6.77a	5.66a	7.00a
Tigoni	Fresh	6.69ab	6.53a	6.53a	6.76a	6.15a
	Frozen	6.44bc	6.11ab	5.88bcd	5.55a	6.44abc
Kenya Sifa	Fresh	6.53ab	6.57a	6.34ab	6.65a	6.53a
	Frozen	6.55b	6.55a	6.77a	5.78a	6.88ab
Kenya Karibu	Fresh	6.31bc	6.34a	6.30abc	6.69a	6.07a
	Frozen	6.42bc	6.01ab	5.8bcd	5.50a	6.34abc
391691.96	Fresh	6.53ab	6.57a	6.34ab	6.65a	6.53a
	Frozen	5.77d	5.89abc	6.67a	5.88bc	6.33bcd
Dutch Robyjn	Fresh	5.92cd	6.53a	6.53a	6.46a	6.53a
	Frozen	6.55b	6.22ab	6.33ab	5.44ab	6.55ab
393385.47	Fresh	5.54d	5.53cd	5.61de	5.73b	5.53b
	Frozen	4.77ef	5.22d	5.55cde	5.00e	5.22e
393385.39	Fresh	5.33e	5.53b	5.82cd	5.92b	5.30b
	Frozen	4.77ef	4.66d	5.33ed	5.11e	5.00f
CV (%)		2.70	2.93	4.43	3.70	2.95
LSD (P≤0.05)		0.41	0.43	0.45	0.42	0.42

Means with the same letter in the same column are not significantly different.
Evaluation was done on 9-point hedonic scale; 5 was the acceptable lower limit.

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