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Effect of Slice Thickness and Frying Temperature on Color, Texture and Sensory Properties of Crisps made from Four Kenyan Potato Cultivars

[1]George O. Abong', [1]Michael W. Okoth, [1]Jasper K. Imungi and [2]Jackson N. Kabira
[1]Department of Food Sciences, Nutrition and Technology, University of Nairobi, P.O. Box 29053-00625, Nairobi (Kangemi), Kenya
[2]National Potato Research Centre (KARI), Tigoni, P.O. Box 338, Limuru, Kenya

Corresponding Author: George O. Abong, Department of Food Sciences, Nutrition and Technology, University of Nairobi, P.O. Box 29053-00625, Nairobi (Kangemi), Kenya

ABSTRACT

The objective of this study was to determine the performance of four Kenyan potato cultivars in terms of texture, color and sensory properties when crisps are processed at different slice thickness and frying temperatures. Potato tubers were peeled, washed and cut into slices of thickness 1.0 mm, 1.5 and 2.0 mm. Each size was fried at a constant temperature of 170°C for 2-5 min. For frying temperature evaluation, the potatoes for all cultivars were cut into a uniform thickness of 1.5 mm and fried at temperatures of 160, 170 and 180°C for 2-5 min. There was no significant ($p>0.05$) variation in crisps texture among the four cultivars at different frying temperatures. Texture significantly ($p\leq 0.05$) increased with increase in frying temperature and slice thickness. Potato cultivar and slice thickness significantly ($p\leq 0.05$) influenced the lightness (L*), redness (a*) and yellowness (b*) color parameters. Redness and yellowness parameters significantly ($p\leq 0.05$) decreased with increase in frying temperature. Potato cultivar significantly ($p\leq 0.05$) influenced sensory scores on crisps color, flavor, texture and overall acceptability. Notably, frying temperature did not significantly ($p>0.05$) affect sensory scores. Color scores significantly ($p\leq 0.05$) decreased with increasing slice thickness. The effects of variety, frying temperature and slice thickness on potato crisps quality are apparent and hence the need for crisps processors to properly select not only the cultivars but also the critical processing parameters.

Key words: Maillard reaction, dehydration, potato, frying temperature, sensory properties

INTRODUCTION

Potato crisps are popular products commonly consumed as a snack Worldwide (Kulkarni *et al.*, 1994; Kita, 2002; Knol *et al.*, 2009). Worldwide consumption of potato and potato products has been increasing in the last few decades. In terms of utilization, potato is the fourth food crop in the world (Yasmin *et al.*, 2006; Ali and Javad, 2007) while it occupies the first position both in acreage and production among vegetable crops in the Far East countries such as Bangladesh (Chowdhury *et al.*, 2002). In sub-Saharan Africa, including Kenya, consumption of crisps has increased rapidly in the last decade (Abong *et al.*, 2010). Potato crisps can be defined as thin potato slices that are dehydrated by deep-fat frying to a moisture content of ≥2%. Crisps can also be defined as thin slices of peeled and washed potato tubers, deep-fried until crunchy and to which edible salt (powder or brine) or permitted food grade spices, color and flavor may be added (EAS, 2010; Salvador *et al.*, 2009). Depending on the processor, there are therefore many different types of crisps targeting different consumer preferences.

Frying of potato products is often selected as a method for creating unique flavors, colors and textures in processed foods and is intended to improve overall palatability. In processing of potato crisps, the most important quality characteristics that manufacturers endeavor to control are color and texture. Color has been known to be the most important quality parameter of fried potato products strictly related to consumer perception (Segnini *et al.*, 1999; Krokida *et al.*, 2001; Pedreschi *et al.*, 2005; Santis *et al.*, 2007). It is always critically evaluated by consumers and in most cases forms the basis for selection or rejection of a brand of crisps. Potato crisps color is the result of the Maillard reaction which depends on the content of reducing sugars and proteins, temperature and time of frying. Reducing sugars levels is especially critical when crisps color is to be desirable (Mendoza *et al.*, 2007) and is the concern of not only the farmers, but the processors of potato products (Sharma *et al.*, 2011).

Changes in texture in the potato slices during frying in both the initial tissue softening process and the later crust development process have been shown to be influenced by temperature (Pedreschi and Moyano, 2005). Higher temperatures were shown to accelerate textural changes. However, neither the temperature nor the pre-treatment such as blanching had a significant effect on the final texture of the fried potato crisps from Chilean cv. Panda (Pedreschi and Moyano, 2005). Kita *et al.* (2007) found no significant influence of frying temperature on the texture of potato crisps fried in sunflower, soybean, palm and the two modified oils. Crisps fried in rapeseed and peanut oils, however, exhibited harder and less crispy texture when they were fried at 150 compared to 180°C. Most variable texture, depending on frying temperature, was in crisps fried in olive oil; it was hardest at lower frying temperature and crispy at highest.

Frying in hot oil at temperatures between 160 and 180°C is normally characterized by very high drying rates that are critical for ensuring favorable structural and textural properties of the final product (Baumann and Escher, 1995). Potato crisps have an oil content that ranges from 30 to 45% (wet basis) that gives the product the unique and desirable texture-flavor combination (Mellema, 2003). In products with relatively high content of starch, such as potatoes, the major influence on texture has been attributed to gelatinization of starch, dehydration, protein denaturation and oil uptake during heating. The crispy structure of crisps results from changes at the cellular and sub-cellular level in the outermost layers of the product (Andersson *et al.*, 1994; Bouchon *et al.*, 2001). The crispy/crunchy character is an important sensory characteristic on which consumers base their appreciation (Van Vliet *et al.*, 2007).

The objective of this study was to determine the performance of four Kenyan potato cultivars in terms of texture, color and sensory properties when crisps are processed in different slice thickness and frying temperature.

MATERIALS AND METHODS

Potato for processing: Two potato clones coded as 391691.96 and 393385.39 from the International Potato Center (CIP) and two established varieties (Tigoni and Dutch Robyjn) were grown at the National Potato Research Center Tigoni, Kenya in the year 2010 under the standard cultural conditions (Lunghao and Kabira, 1999). After maturity, the crop was dehaulmed two weeks before harvesting. Following harvest, the tubers were allowed to cure in a common dark store under ambient air conditions (17-22°C/84-92% rh) for two weeks at the National Potato Research

Center in Tigoni. They were then processed into crisps in Tigoni and analyzed for sensory properties. The products were analyzed for color and texture in the Department of Food Science and Technology laboratories, Jomo Kenyatta University of Agriculture and Technology.

Extraction and determination of sugars: Approximately 10 g of homogenized potato slices and finely ground crisps were weighed into a 250 mL conical flask and 50 mL of 96% alcohol was added and mixed well. The mixture was refluxed at 100°C for 1 h, stirring occasionally. The resultant slurry was filtered and the filtrate collected. The conical flask was rinsed 3 times with 5 mL of 80% alcohol. The filtrate was transferred into 150 mL pear-shaped flask and the solvent evaporated to dryness at 60°C. Approximately 10 mL of distilled water was added to the dried sample. Thereafter the dissolved sample was placed in duplicates of 2 mL into a test tube and 2 mL of diethyl ether added. The mixture was vigorously shaken and allowed to stand before removing the ether layer. This was repeated 3 times. Excess ether was flashed off using a vacuum (Heraeus, RVT 360, Germany). Equal amounts of acetonitrile were added to the samples before being stored at 5°C ready for determination of sugars using HPLC.

The samples were micro-filtered to remove any debris before injecting 20 µL into a HPLC, SCL-10A (Shimadzu, Japan) fitted with a Refractive Index Detector, RID-6A (Shimadzu, Japan). Chromatographic conditions included a mobile phase of acetonitrile: water (75:25) pumped through a reverse phase column, $NH_2$100R 250×4.6 mm, 5 µm at a working maximum pressure of 150 kgf cm^{-2} and flow rate of 1.0 mL min^{-1}. Oven temperature was set at 30°C. Using working standards of sucrose, fructose and glucose, the sugars in the samples were identified and calculated. The results are means of duplicate determinations and are given as fructose, glucose and sucrose in g/100 g dry weight (dw). Tubers of reducing sugars levels $\le$0.25% were considered acceptable for processing.

Potato crisps processing: Duplicate 10 potato tubers from each cultivar were peeled and sliced using an automatic electric slicer (Hitech Systems, Saudi Arabia) to uniform thicknesses of 1.0, 1.5 and 2.0 mm. The slices were washed in cold water to remove surface starch, dried with a cloth towel and fried at a constant temperature of 170°C for 2-5 min in an institution size, batch type, deep oil fryer (E 6 ARO S.A., La Neuveville, Switzerland) containing about 7 L of “Chef” corn oil (Premier Oil Mills Ltd., Nairobi, Kenya). For frying temperature evaluations, ten tubers from each cultivar were cut into a uniform thickness of 1.5 mm and duplicate samples of 200 g slices were fried in oil heated at temperatures of 160, 170 and 180°C for 2-5 min. The fried slices were removed and excess oil drained off for 1 min, placed on plates and cooled before evaluation.

Color measurements: Crisps color was measured using a color spectrophotometer (NF 333, Nippon Denshoku, Japan) using the CIE Lab L*, a* and b* color scale. The ‘L*’ value is the lightness parameter indicating degree of sample lightness varying from 0 = black to 100 = white. The ‘a*’ which is the chromatic redness parameter whose value means red color when positive (+) and green color when negative (-). The ‘b*’ is yellowness chromatic parameter corresponding to yellow color when positive (+) and blue color when negative (-). Each sample consisted of 10 crisps pieces, each of which was measured twice.

Texture measurements: Crisps texture measurements were performed at room temperature (23°C) by a puncture test using a Texture Analyzer (Sun rheometer Compac 100, Sun scientific Co.

Ltd, Japan) equipped with a wedge probe imitating front teeth. Maximum force needed at a penetration rate of 100 mm min^{-1} was recorded. Maximum Force (MF) is defined as the force at which the wedge penetrates the outer layer of the surface of the fried potato slices (Segnini *et al.*, 1999). Each measurement was conducted on 10 potato crisps as described by Van Vliet *et al.* (2007).

Sensory evaluation: Coded samples were presented in duplicates to 20 panelists, all familiar with potato crisps. Panel members scored for flavor, oiliness and overall acceptability on a 7-point hedonic rating scale varying from 1 (dislike very much) to 7 (like very much). A score of 4 was the lower limit of acceptability (Larmond, 1977).

Data analysis: One-way analysis of variance (ANOVA) and least significant difference test for the variables was conducted using the Statistical Analysis System (SAS version 9). Correlation coefficients (ANOVA) were performed to determine relationship between color and texture determined by laboratory and sensory scores on the parameters. Differences at $p \le 0.05$ were considered significant.

RESULTS AND DISCUSSION

Influence of temperature and slice thickness on crisps texture: There was no significant ($p>0.05$) variation in crisps texture among the four cultivars that were evaluated (Table 1).

Cultivar-temperature interaction had no significant ($p>0.05$) effect on texture. Texture, however, significantly ($p \le 0.05$) increased with increase in frying temperature. The effect of temperature on texture was minimal in cv. Dutch Robyjn and 391691.96 when compared to cv. Tigoni and 393385.39 that had greater changes.

These results slightly differ from those reported by Kita *et al.* (2007) who worked on a potato cv. Karlena and observed that frying temperatures had no significant influence on the texture of potato crisps fried in sunflower, soybean, palm and modified oils. This difference may be attributed the nature of raw materials such as potato cultivars and type of frying oil. Whereas the authors used one potato variety to carry out the experiments, this study looked at four cultivars. Their study, however, indicated that, depending on frying temperature, crisps fried in olive oil were hardest at lower frying temperature and crispy at highest.

Notably, there were no significant ($p \le 0.05$) differences between texture of crisps fried at 170 and 180°C. This means that frying crisps at either temperature will not influence the texture of potato crisps. This finding is important with regard to acrylamide formation in potato crisps. It is possible to reduce acrylamide content of potato crisps without adverse effect on its textural quality, by decreasing frying temperature (Pedreschi *et al.*, 2005).

There was no significant ($p>0.05$) correlation ($r = 0.07$) between sensory texture scores and maximum force (N) measured by texture analyzer. This means that consumers may not be able to detect any textural differences in crisps made from the four potato cultivars. Potato crisps texture is influenced among other factors with dry matter content and processing temperature. The higher the temperature, the less the oil absorbed and the higher the water which is evaporated from crisps slices; the crispier the slices become (Lisinska and Golubowska, 2005). The presence of oil in a cellular solid crispy material, for instance, is known to greatly affect the sound emitted on fracture at least for shorter ageing times (Van Vliet *et al.*, 2007). Results of the present study strongly agree with these findings due to the fact that the maximum force (texture) increased with increase in frying temperature.

Table 1: Average crisps texture (N) values depending on frying temperature

	Texture (maximum force)		
Cultivar	160°C	170°C	180°C
391692	0.24±0.03	0.25±0.03	0.25±0.04
393385.4	0.21±0.03	0.25±0.07	0.27±0.08
Tigoni	0.19±0.01	0.22±0.08	0.27±0.08
Dutch Robyjn	0.26±0.05	0.26±0.02	0.27±0.02

Values are as Mean±SD

Table 2: Average texture (N) values of potato crisps as affected by slice thickness

	Texture (maximum force) at		
Cultivar	1.0 mm	1.5 mm	2.0 mm
391692	0.06±0.01	0.22±0.01	0.34±0.15
393385.4	0.06±0.03	0.20±0.02	0.27±0.02
Tigoni	0.12±0.01	0.19±0.05	0.24±0.09
Dutch Robyjn	0.09±0.02	0.21±0.08	0.29±0.07

Values are as Mean±SD

Table 2 summarizes the textural scores of crisps from four Kenyan cultivars as influenced by slice thickness.

The four cultivars significantly ($p \leq 0.05$) varied in texture when processed at different slice thicknesses. Cultivar-size interaction had no significant ($p>0.05$) effect on texture. Crisps from cv. Tigoni were the hardest (higher textural scores) at 1.0 mm and 391691.96 were the hardest at 1.5 mm and 2.0 mm. The maximum force to break the crisps significantly ($p \leq 0.05$) increased with increase in slice thickness. There was, however, no significant ($p>0.05$) correlation coefficient ($r = 0.22$) between texture determined in the laboratory and sensory scores indicating that panelists could not detect differences in texture as affected by slice thickness and any crisps size would be acceptable so long as they are attractive.

Influence of temperature and slice thickness on crisps color parameters: Potato cultivar significantly ($p \leq 0.001$) influenced the lightness (L*) parameter; it was highest in crisps of cv. 391691.96 followed by Dutch Robyjn and Tigoni while it was lowest in cv. 393385.39 (Table 3, 4).

Frying temperature, however, did not significantly ($p>0.05$) influence the lightness parameter and the cultivar-temperature interaction had no significant influence on lightness. Crisps from the four cultivars significantly ($p \leq 0.001$) differed in redness parameter (a*); cv. Tigoni and 393385.39 tended towards red (positive values) while with negative values of crisps from 391691.96 and Dutch Robyjn tended towards green. The parameter was significantly ($p \leq 0.001$) affected by cultivar-temperature interaction; crisps color tended towards red (browning) in all the cultivars as temperature increased from 160 to 180°C, respectively. Redness or crisps darkening which increases with increase in frying temperatures is mainly due to formation of acrylamide contents which utilizes the available reducing sugars (Pedreschia *et al.*, 2004).

Yellowness (b*) parameter significantly ($p \leq 0.001$) differed with potato cultivars, it was highest in clone 391691.96 followed by varieties Dutch Robyjn and Tigoni while it was lowest in clone 393385.39. All the cultivars produced crisps which tended towards yellow color. Yellowness

Table 3: Analysis of variance for fructose, glucose, sucrose, crisp colour and texture of tubers from four Kenyan potato cultivars processed at three temperatures and in three different slice thicknesses

Source	df	Fructose	Glucose	Sucrose	Reducing sugars	L*	a*	b*	Texture (N)
Cultivar (C)	3	***	***	**	***	***	***	***	NS
Temperature (T)	2	***	***	***	***	NS	**	**	**
Slice thickness (S)	2	NA	NA	NA	NA	***	*	***	**
C * T	6	**	**	NS	*	***	***	**	NS
C * S	6	NA	NA	NA	NA	**	*	NS	NS

df: Degrees of freedom, Levels of significance: *$p \le 0.05$, **$p \le 0.01$, ***$p \le 0.001$, L*: Lightness, a*: Redness, b*: Yellowness, NS: Not significant, $p > 0.05$, NA: Not applicable

Table 4: Effect of frying temperature on color parameters of potato crisps from four Kenyan cultivars

Cultivar	Temperature (°C)	Lightness (L*)	Redness (a*)	Yellowness (b*)
391692	160	70.34±2.56	-1.43±0.21	23.15±0.93
	170	70.90±3.35	-0.27±0.10	22.89±1.58
	180	64.44±1.00	-0.21±0.42	22.90±2.05
393385.4	160	60.05±2.49	-0.12±0.43	18.00±0.82
	170	58.63±5.20	0.19±0.56	17.79±1.62
	180	63.00±1.66	0.69±0.39	19.97±0.87
Dutch Robyjn	160	63.15±2.29	-0.96±0.53	18.43±2.06
	170	64.59±4.61	-0.73±0.32	23.56±2.36
	180	67.11±0.91	-0.25±0.22	21.26±0.66
Tigoni	160	60.05±2.49	-0.17±0.43	18.00±0.81
	170	59.12±4.95	0.19±0.42	18.31±0.72
	180	67.30±2.91	1.23±1.28	20.07±0.83

significantly ($p \le 0.01$) increased with frying temperature in Tigoni and 393385.39 while it did not have a definite trend in 391691.96 and Dutch Robyjn. The higher frying temperature requires less time compared to lower temperatures which could explain this noted behavior. The differences in the behavior of the cultivar may also have resulted from the different composition especially in reducing sugars of the cultivars, especially levels of glucose (Table 5).

Color of potato crisps is an important parameter to be controlled during processing together with crispness, oil and acrylamide content. Potato crisps color, just like flavor and aroma compounds, is formed by the maillard reaction between reducing sugars and amino acids which occur naturally at different levels in potatoes depending on variety (Pedreschi *et al.*, 2005; Santis *et al.*, 2007; Williams, 2005; Hassanpanah *et al.*, 2011). The tendency to brown or darken in crisps increases at higher levels of reducing sugars (Olsson *et al.*, 2004; Viklund *et al.*, 2010). The four cultivars had acceptable sugar levels. However, Dutch Robyjn and clone 391691.96 had lower sugars compared to Tigoni and 393385.39 and are therefore, expected to have good fry colors. In industrial processing of potato crisps, potato slices are normally deep fried at 150-180°C for 2-5 min, during which time the moisture content in the potato slices decreases from approximately 75 to<2%. Apart from sugars and amino acids which influence crisps' tendency to darken, high frying temperatures can also lead to production of dark colored crisps (Viklund *et al.*, 2004).

The color parameters of crisps from the four cultivars as affected by slice thickness are shown in Table 6. The cultivars varied significantly ($p \le 0.001$) in lightness (L*) parameter; cv. 393385.39 had the highest average value (63.72) followed by Tigoni (60.28) and 391691.96 (58.70) while Dutch Robyjn had the lowest value (58.39).

Table 5: Variation in sugars levels in four potato cultivars as affected by three frying temperatures

Cultivar	Treatment	Fructose	Glucose	Sucrose	Reducing sugars
Dutch Robyjn	Raw	0.034±0.000	0.101±0.000	0.055±0.001	0.135±0.003
	160°C	0.001±0.001	0.041±0.003	0.041±0.001	0.063±0.003
	170°C	0.001±0.001	0.036±0.001	0.035±0.000	0.052±0.006
	180°C	0.000±0.000	0.019±0.000	0.028±0.003	0.037±0.004
391692	Raw	0.047±0.013	0.076±0.002	0.056±0.002	0.123±0.002
	160°C	0.021±0.001	0.032±0.000	0.036±0.003	0.068±0.003
	170°C	0.013±0.001	0.020±0.000	0.029±0.001	0.051±0.000
	180°C	0.001±0.000	0.009±0.001	0.015±0.008	0.017±0.011
393385.4	Raw	0.050±0.002	0.050±0.008	0.250±0.053	0.168±0.042
	T160°C	0.013±0.001	0.020±0.000	0.005±0.001	0.037±0.001
	T170°C	0.001±0.001	0.001±0.000	0.003±0.000	0.004±0.001
	T180°C	0.001±0.000	0.000±0.000	0.001±0.000	0.002±0.001
Tigoni	Raw	0.113±0.003	0.076±0.001	0.131±0.001	0.193±0.005
	160°C	0.021±0.001	0.015±0.002	0.014±0.000	0.049±0.004
	170°C	0.020±0.000	0.012±0.000	0.004±0.000	0.035±0.001
	180°C	0.025±0.007	0.001±0.001	0.002±0.000	0.034±0.009

Table 6: Color parameters of potato crisps made from four potato cultivars depending on slice thickness

Cultivar	Slice thickness (mm)	Lightness (L*)	Redness (a*)	Yellowness (b*)
391692	1.0	66.61±1.85	-2.57±0.53	23.70±2.08
	1.5	57.02±3.50	-0.14±1.50	21.00±2.16
	2.0	52.45±3.49	0.51±0.80	15.76±1.38
393385.4	1.0	71.49±3.58	0.23±1.46	23.90±3.17
	1.5	62.69±3.27	1.12±0.72	19.81±0.67
	2.0	56.98±3.32	0.19±0.84	17.45±2.59
Dutch Robyjn	1.0	58.32±2.01	-0.46±0.63	22.56±1.05
	1.5	62.28±2.96	-0.67±0.15	23.35±4.30
	2.0	54.55±2.71	-1.11±1.13	20.19±1.27
Tigoni	1.0	64.21±1.83	-0.21±0.39	19.07±3.59
	1.5	62.08±3.34	0.02±1.05	15.64±0.82
	2.0	54.55±1.69	1.26±0.73	14.94±0.80

Lightness values significantly ($p \leq 0.01$) decreased with increasing slice thickness in all the cultivars indicating significant cultivar-size interaction. Redness (a*) value significantly ($p \leq 0.05$) differed in crisps depending on cultivar; cv. 393385.39 and Tigoni produced crisps with colors tending towards red compared to cv. 391691.96 and Dutch Robyjn which tended towards green. Redness parameter significantly ($p \leq 0.05$) increased with increase in slice thickness. Thin slices may have had very little amounts of precursors combined with short frying times that lead to reduced redness or darkening of crisps.

The degree of yellowness (b*) varied significantly ($p \leq 0.05$) with cultivar; it was highest in cv. Dutch Robyjn followed by 393385.39 and 391691.96, respectively. Variety Tigoni had the lowest values. Yellowness value significantly ($p \leq 0.05$) decreased with increase in slice thickness.

Sensory properties of crisps produced from four potato cultivars: Potato cultivar significantly ($p \leq 0.05$) influenced crisps color, flavor, texture and overall acceptability (Table 7). Variety Dutch Robyjn had the highest color score (>5) while clone 391691.96 had the lowest score

Table 7: Sensory properties of four potato cultivars as affected by frying temperature

Cultivar	Frying temperature (°C)	Color	Flavor	Texture	Overall acceptability
Dutch Robyjn	160	6.0±1.12	5.5±1.44	5.6±0.99	5.3±0.96
	170	5.7±0.98	5.2±0.70	5.2±0.72	5.2±0.72
	180	5.5±0.79	5.3±0.86	5.1±0.71	5.6±0.90
393385.4	160	4.9±1.08	5.4±0.79	4.7±0.96	4.9±1.24
	170	4.6±1.07	4.5±0.52	4.8±0.83	5.2±0.83
	180	5.2±1.33	5.4±1.38	5.3±1.21	5.3±1.22
391692	160	4.0±0.85	4.2±0.72	4.3±1.21	4.3±1.15
	170	4.5±0.78	4.4±1.00	4.6±0.99	4.9±0.90
	180	4.0±0.80	4.2±1.11	4.3±1.29	4.0±0.85
Tigoni	160	4.9±1.44	4.3±0.65	5.2±0.71	4.8±1.05
	170	4.4±1.31	4.9±1.08	4.6±1.30	4.5±1.31
	180	5.6±1.44	5.1±1.08	5.3±1.28	5.6±1.24

Table 8: Sensory properties of four potato cultivars as affected by frying temperature

Cultivar	Slice thickness (mm)	Color	Flavour	Texture	Overall acceptability
Dutch Robyjn	2.0	5.3±1.12	5.4±1.08	5.3±1.36	5.3±0.98
	1.5	5.0±1.60	5.0±1.35	5.6±0.99	5.5±1.17
	1.0	4.9±1.31	5.1±1.16	5.3±1.28	5.9±0.67
393385.4	2.0	6.3±0.45	6.0±0.60	5.8±0.58	6.2±0.39
	1.5	5.5±0.79	5.2±1.11	5.5±0.80	5.8±0.62
	1.0	4.9±1.31	4.8±1.11	5.0±1.21	5.3±0.96
391692	2.0	5.7±1.30	5.1±0.90	5.6±0.79	5.6±0.90
	1.5	5.6±1.00	5.8±0.97	5.6±0.75	5.8±0.93
	1.0	4.7±0.75	4.8±0.75	5.6±0.90	5.8±0.75
Tigoni	2.0	5.0±1.41	4.6±1.44	4.8±1.21	4.8±1.29
	1.5	5.8±1.40	5.5±1.17	5.3±1.30	5.5±1.31
	1.0	5.0±1.13	5.3±1.07	5.6±1.16	5.6±1.00

(4.0) at all the frying temperatures. Frying temperature did not significantly ($p>0.05$) affect potato crisps color and flavor in all the cultivars. Scores for texture were significantly ($p\leq 0.05$) higher in Dutch Robyjn and Tigoni than in clones 393385.39 and 391691.96. Even though panel scores were generally higher at frying temperatures of 180°C, crisps texture did not follow any specific pattern; frying temperature did not significantly ($p>0.05$) influence scores on texture. These results agree with Rojo and Vincent (2008) who worked on three commercial potato crisps.

Table 8 summarizes sensory properties of potato crisps as influenced by slice thickness. All the cultivars produced acceptable potato crisps. Potato cultivar did not significantly ($p>0.05$) influence the scores of crisps color, flavor and texture when slices of different thickness were fried. Slice thickness, however significantly ($p\leq 0.05$) influenced color scores of the potato crisps; the smaller the slice, the higher the score. There was, however, no significant effect of thickness on flavor and texture of crisps. Color of the food surface is the first quality parameter evaluated by consumers and is critical in the acceptance of the product, even before it enters the mouth (Santis *et al*., 2007). It is therefore, important to select slice thickness that will produce products with acceptable color and other sensory attributes.

CONCLUSION AND RECOMMENDATION

Texture and color of potato crisps were influenced by potato cultivar, slice thickness and frying temperature. Frying at temperatures of 170 and 180°C produced better results compared with

160°C. Sensory properties of potato crisps of the four cultivars were affected by slice thickness and frying temperature. Cultivars Dutch Robyjn and 391691.96 performed better in comparison to 393385.39 and Tigoni. Processors should therefore properly select not only the cultivars, but also the slice thickness in order to produce attractive and acceptable potato crisps.

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REFERENCES

Abong, G.O., M.W. Okoth, J.K. Imungi and J.N. Kabira, 2010. Consumption patterns, diversity and characteristics of potato crisps in Nairobi, Kenya. J. Applied Biosci., 32: 1942-1955.

Ali, A. and L. Javad, 2007. Study on variation of potato varieties using electrophoretic tuber storage proteins. Pak. J. Biol. Sci., 10: 3195-3199.

Andersson, A., A. Gekas, I. Lind, F. Oliveira and R. Oste, 1994. Effect of preheating on potato texture. Crit. Rev. Food Sci. Nutr., 34: 229-251.

Baumann, B. and F. Escher, 1995. Mass and heat transfer during deep fat frying of potato slices I. Rate of drying and oil uptake. Food Sci. Technol., 28: 395-403.

Bouchon, P., P. Hollins, M. Pearson, D.L. Pyle and M.J. Tobin, 2001. Oil distribution in fried potatoes monitored by infrared microspectroscopy. J. Food Sci., 66: 918-923.

Chowdhury, M.R.I., A.K.M.G. Sarwar and A.M. Farooque, 2002. Effect of different methods of urea application on growth and yield in potato. Asian J. Plant Sci., 1: 672-674.

EAS, 2010. Potato Crisps Specifications. 1st Edn., East African Standards, USA..

Hassanpanah, D., H. Hassanabadi and S.H.A. Chakherchaman, 2011. Evaluation of cooking quality characteristics of advanced clones and potato cultivars. Am. J. Food Technol., 6: 72-79.

Kita, A., 2002. The influence of potato chemical composition on crisp texture. Food Chem., 76: 173-179.

Kita, A., G. Lisinska, G. Golubowska, 2007. The effects of oils and frying temperatures on the texture and fat content of potato crisps. Food Chem., 102: 1-5.

Knol, J.J., G.A.I. Viklund, J.P.H. Linssen, I.M. Sjoholm, K.M. Skog and M.A.J.S. van Boekel, 2009. Kinetic modelling: A tool to predict the formation of acrylamide in potato crisps. Food Chem., 113: 103-109.

Krokida, M.K., Z.B. Maroulis and G.D. Saravacos, 2001. The effect of the method of drying on the colour of dehydrated products. Int. J. Food Sci. Technol., 36: 53-59.

Kulkarni, K.D., N. Govinden and D.N. Kulkarni, 1994. Crisp quality of two potato varieties: Effects of dehydration and rehydration. J. Sci. Food Agric., 64: 205-210.

Larmond, E., 1977. Methods for Sensory Evaluation of Food. Food Research Institute, Ottawa, Canada.

Lisinska, G. and G. Golubowska, 2005. Structural changes of potato tissue during French fries production. Food Chem., 93: 681-687.

Lunghao, C. and J.N. Kabira, 1999. A Guide to Growing Table Potatoes. Kenya Agricultural Research Institute, Nairobi, Kenya..

Mellema, M., 2003. Mechanism and reduction of fat uptake in deep-fat fried foods. Trends Food Sci. Technol., 14: 364-373.

Mendoza, F., P. Dejmek and J.M. Aguilera, 2007. Colour and image texture analysis in classification of commercial potato chips. Food Res. Int., 40: 1146-1154.

Olsson, K., R. Svensson and C.A. Roslund, 2004. Tuber components affecting acrylamide formation and colour in fried potato: Variation by variety, year, storage temperature and storage time. J. Sci. Food Agric., 84: 447-458.

Pedreschi, F., K. Kaack and K. Granby, 2004. Reduction of acrylamide formation in potato slices during frying. Food Sci. Technol., 37: 679-685.

Pedreschi, F., P. Moyano, K. Kaack and K. Granby, 2005. Color changes and acrylamide formation in fried potato slices. Food Res. Int., 38: 1-9.

Pedreschi, F. and P. Moyano, 2005. Oil uptake and texture development in fried potato slices. J. Food Eng., 70: 557-563.

Rojo, F.J. and J.F.V. Vincent, 2008. Fracture properties of potato crisps. Int. J. Food Sci. Technol., 43: 752-760.

Salvador, A., P. Varela, T. Sanz and S.M. Fiszman, 2009. Understanding potato chips crispy texture by simultaneous fracture and acoustic measurements and sensory analysis. Food Sci. Technol., 42: 763-767.

Santis, N., F. Mendoza, P. Moyano, F. Pedreschi and P. Dejmek, 2007. Soaking in a NaCl solution produce paler potato chips. Food Sci. Technol., 40: 307-312.

Segnini, S., P. Dejmek and R. Oste, 1999. Reproducible texture analysis of potato chips. J. Food Sci., 64: 309-312.

Sharma, D.K., S.S. Kushwah, P.K. Nema and S.S. Rathore, 2011. Effect of sulphur on yield and quality of potato (*Solanum tuberosum* L.). Int. J. Agric. Res., 6: 143-148.

Van Vliet, T., J.E. Visser and H. Luyten, 2007. On the mechanism by which oil uptake decreases crispy/crunchy behaviour of fried products. Food Res. Int., 40: 1122-1128.

Viklund, G., F. Mendoza, I. Sjoholma and K. Skog, 2004. An experimental set-up for studying acrylamide formation in potato crisps. Food Sci. Technol., 40: 1066-1071.

Viklund, G.A.I., K.M. Olsson, I.M. Sjoholm and K.I. Skog, 2010. Acrylamide in crisps: Effect of blanching studied on long-term stored potato clones. J. Food Compos. Anal., 23: 194-196.

Williams, J.S.E., 2005. Influence of variety and processing conditions on acrylamide levels in potato crisps. Food Chem., 90: 875-881.

Yasmin, S., M. Shahidul Islam, M. Khondoker Nasiruddin and M. Samsul Alam, 2006. Molecular characterization of potato germplasm by random amplified polymorphic DNA markers. Biotechnology, 5: 27-31.