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SENSORY QUALITY OF BOILED POTATO CLONES AND SPUNTA USING QUANTITATIVE DESCRIPTIVE ANALYSIS (QDA) AND INSTRUMENTAL COLOUR MEASUREMENT

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ABSTRACT: The selection of advanced potato clones for their culinary characteristics as table potato is a major research activity in the breeding and selection programme at the Food and Agricultural and Extension Institute. The objective of this study was to assess the sensory quality of six advanced potato clones and Spunta variety using boiling as a cooking method. Quantitative Descriptive Analysis (QDA) was applied to develop sensory profiles. A trained sensory panel of 7 assessors identified 16 descriptors comprising of 3 appearance, 5 texture, 4 aroma, 3 flavour and 1 taste characteristics. Sensory data showed that all potato clones obtained significantly higher mean ratings for white colour but significantly lower values for yellow colour compared to Spunta ($P \leq 0.05$). These results were consistent with the instrumental CIE b* measurements for yellowness. Mean sensory ratings for most texture descriptors (compressibility, stickiness and dryness) were not significantly different between clone 29/5/16 and Spunta ($P \geq 0.05$). On the other hand, Spunta obtained a significantly higher mean boiled potato aroma rating than all clones ($P \leq 0.05$) while the mean sensory ratings for potato–like flavour of 29/5/14, 29/5/16 and 142/16 1/5 were not significantly different from the corresponding values for Spunta ($P \geq 0.05$). Texture and flavour profiles indicated suitability of potato clone 29/5/16 and Spunta for the development of boiled potato products.

KEYWORDS: potato clones, Spunta, boiled potato, sensory quality, Quantitative Descriptive Analysis (QDA), instrumental colour

INTRODUCTION

Potato (*Solanum tuberosum* L.) is the fourth most important food crop in the world after maize, wheat and rice (FAOSTAT, 2021; OECD/FAO, 2022). In Mauritius, it is the most cultivated and most consumed among all food crops with a per capita consumption of 19.64 kg/year (Statistics Mauritius, 2022).

Boiled potatoes contribute to a sustainable diet with a good source of several B vitamins, vitamin C, dietary fibre, potassium, folate and iron (Camire *et al.,* 2009). They are rich in carbohydrates and energy and have little fat (Camire *et al.,* 2009). In addition, they contain a lot of antioxidants and have a very high rating of satiety (Gustavsen, 2021). A survey among households in urban, semi-urban and rural areas in Mauritius indicated that potato is used for six main purposes: curry (25.4%), crisps (17.3%), French fries (15.5%), stew (fricassée or daube) (15.5%), mash (11%)

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and salad (10.9%) (Govinden *et al.*, 1997). Furthermore, Gunputh (2009) found that among housewives of different age groups and with diverse cultural backgrounds, the percentage respondents expressing that they "very often" utilised potato for dish preparation was highest for curry (42.5%), crisps (44.2%) and French fries (42.5%). These findings highlight the importance of boiled potato in curry and mash recipes although culinary choices in a typical Mauritian diet are limited. The selection of potato clones for their culinary use is a major thrust in the Research and Development programme at the Food and Agricultural Research and Extension Institute (FAREI).

Recently, eighteen advanced potato clones were selected for the fresh and processed market segments based on their tuber characteristics and dry matter content (Cadersa *et al.*, 2019). During the advanced stages of selection, six promising clones were identified as high-yielding and late blight resistant compared to Spunta which is the most popular table potato variety. It is important to determine whether these promising local clones are suitable for boiled table potatoes to replace the Spunta variety. Quantitative Descriptive Analysis (QDA) is being used to assess the organoleptic properties including appearance, texture, aroma, flavour, taste and after taste of foods and beverages (Meilgaard *et al.*, 2007; Cruz *et al.*, 2010) by using human assessors as measuring instruments (Kemp *et al.*, 2018). The objectives of this study were to (i) identify the sensory descriptors of boiled potato clones and Spunta using QDA (ii) develop the sensory lexicon and measurement scales for each sensory descriptor (iii) rate the perceived intensity of the different sensory descriptors (iv) determine the CIELAB colour variables of the boiled potato genotypes using instrumental measurement and (v) select clones suitable for boiled table potato according to their sensory profiles.

MATERIALS AND METHODS

Potato genotypes

Seven potato clones were used in this study: six advanced clones (142/161/4, 142/161/5, 161/142/16, 29/5/10, 29/5/14 and 29/5/16) and the widely grown commercial variety Spunta. The tuber characteristics of the clones are presented (Table 1, Fig. 1). All clones were grown in the first potato season in May 2020 at the Réduit Crop Research Station and harvested in July 2020. 30 kg tubers of each accession of marketable size (150- 200g) and free from external defects and pathogens were allowed to cure at ambient temperature for 24 hours and then stored at 11-13°C at 80-90% relative humidity for one week before samples were used for sensory training and evaluation sessions. This brief storage period

Table 1. Tuber characteristics of potato clones including the control variety Spunta

Potato genotype	Tuber shape	Eye depth	Skin colour	Flesh colour	Dry matter content (%)
142/161/4	Oval long	Shallow	White cream	White	19.2
142/161/5	Oval round	Shallow	White cream	White	21.3
161/142/16	Oval long	Deep	White cream	Cream	17.4
29/5/10	Oval long	Shallow	White cream	White	22.8
29/5/14	Oval	Shallow	White cream	White	22.9
29/5/16	Oval long	Shallow	White cream	White	19.4
Spunta	Long	Shallow	Yellow	Yellow	22.4

Source: Cadersa *et al*. (2019)

Fig. 1. Tuber characteristics of 6 promising clones and Spunta evaluated for the suitability for boiled potatoes.

ensures wound healing of tubers and stabilises biochemical composition.

Selection of assessors

The sensory panel was made up of the following: (i) selected assessors who were undergraduate students of food science and technology of the University of Mauritius (ii) the panel leader and(iii) the panel supervisor. Details for establishing the sensory profile of boiled potato was in accordance with ISO 8586 (2012) and 1SO13299 (2003(E)). Seven trained assessors (5 females/2 males, aged between 21–24 years) were selected to participate in the development of the sensory profiles and final evaluation of the boiled potato clones. They were chosen from an initial population of 32 candidates based on their sensory acuity, descriptive and discriminating ability in scoring above 80% in the different screening tests namely triangle test, odour recognition test, taste recognition test, jelly- flavour test and colour sensitivity (ISO 8586, 2021), motivation and willingness to participate in the project and availability for the whole duration of the study. Since the panel size was small, rigorous training and monitoring was done to ensure consistency and reliability of data among the panelists.

Training of Assessors

Identification of sensory descriptors and lexicon development

Selected assessors were required to individually identify sensory descriptors of 4 potato samples, namely 3 clones and Spunta variety. Sensory descriptors which were identified by most assessors were retained for quantitative analysis. The list of descriptors was further refined and consolidated using additional documented literature on boiled potato sensory characteristics (Van Marle *et al.*, 1997; Thybo and Martens, 1999; Seefelt *et al.*, 2011) and ISO (International Organisation for Standardisation) reference materials (ISO 5492, 2008). The assessors were introduced to the different terminologies from the following perspectives (i) general terminology (ii) the senses (iii) organoleptic attributes and (iv) sensory methods (ISO 5492, 2008). In addition, they were also introduced to sensory terms used to describe appearance, aroma, flavour, taste and solid oral texture (Meilgaard *et al.*, 2007). Collective discussion of the meaning of each selected sensory descriptor was facilitated by the panel leader to ensure consistent interpretation and reach consensus among the assessors.

Training in the use of quantitative response scales

15 cm unipolar and bipolar line scales with anchors at 2.5 cm were used for quantitative evaluation (ISO 4121, 2003).

Assessors collectively agreed on ratings for the reference materials. The assessors also practiced quantitative assessment of reference materials to ensure that they give close responses to the same sensory stimuli and minimise variation in individual ratings. Boiled potato variety Spunta and boiled sweet potato were the key reference samples for defined points of measurement scales of many sensory descriptors. Boiled sweet potato was chosen because it is a starchy vegetable with similar cooking methods like potato. Fig. 2 shows the agreed ratings of reference materials for texture, aroma and taste descriptors.

Training and monitoring

Selected assessors undertook two- hour training sessions every week from 05 March 2020 to 13 March 2020 and from 06 August to 17 September totalling 20 hrs. Training sessions started with appearance and texture descriptors followed by aroma, flavour and taste attributes. A standard procedure for order and method of sensory evaluation was developed to control sources of variations. For appearance descriptors, assessors were provided with longitudinal sections of boiled potato tubers (7cm × 3.5 cm) in open containers and presented on a white background. They were requested to rate the perceived intensity of each colour descriptor by carefully examining the sample under a source of light and assessing the proportion of white, cream or yellow colour which can be observed on the sample surface. For describing oral texture descriptors, assessors were required to place a piece of the boiled potato sample of controlled size between incisor teeth, bite half of the sample with incisors and chew down with molar teeth.

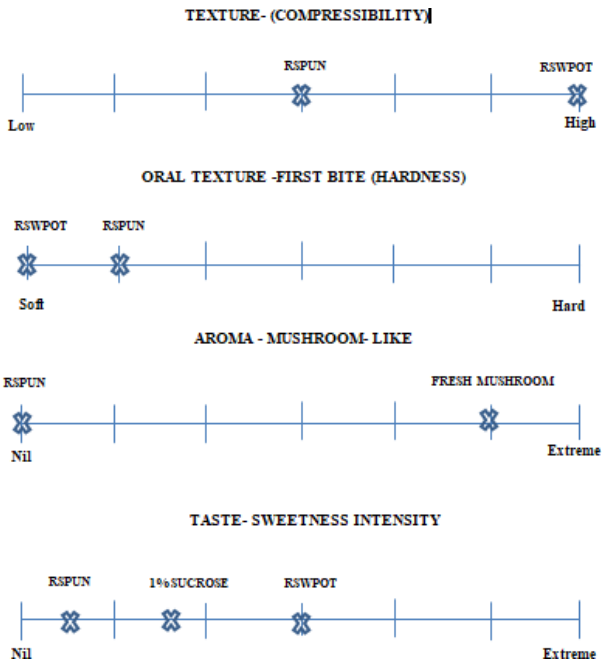

Fig. 2. Unipolar and bipolar line scales showing the agreed ratings for reference materials. Examples are given for texture, aroma and taste descriptors. Lines are not drawn to scale. The respective crosses on the line represent the corresponding ratings for the different reference materials (RSPUN- reference Spunta; RSWPOT- reference sweet potato).

For aroma, flavour and taste descriptors, boiled potato samples were provided in closed containers. To ensure effective detection, recognition and quantification of aroma descriptors, assessors were instructed to bring the sample container close to their nose, take a few short sniffs and concentrate on the perceived intensity of the odour. They were required to close the container immediately after smelling the samples to prevent volatile odour compounds of one sample from interfering with odour assessment of other samples. This was also important to allow the volatiles to concentrate in the headspace of the sample container.

Monitoring tests involving blind coded samples/reference materials were implemented to evaluate the effectiveness of the training sessions in terms of bias and between-assessor variation. Assessor's bias was estimated from the difference between the individual monitoring rating for the sensory descriptor of a sample/reference material and the collectively agreed rating during training

sessions for the specific descriptor and same sample/reference as follows: Assessor bias (d) = x - μ where d is the deviation or bias, x is the observed assessor rating, and μ is the corresponding agreed rating (Meilgaard *et al.,* 2007).

Retraining was conducted for specific descriptors namely white and cream colour, rancid-like and mushroom- like aroma and flavour to ensure that assessors achieve consistent results by using the same part of the scale when evaluating the same sample.

Sensory profiling

Preparation of boiled potato samples

The potato samples were washed in running water to remove any soil or dirt present on the surface of the tubers. Two uniform sized tubers (200 – 250g each per accession) were placed into 2-L stainless steel saucepans, covered with 1.25–1.50 L water and boiled with their skins for approximately 45 minutes with a lid on the saucepan to prevent excessive moisture loss. The water was replenished as and when required to ensure that it covered the potato tubers. The potato samples were cooked until soft by inserting a fork in the centre of the tubers and removing it without resistance. The cooked potatoes were removed from the saucepan and allowed to cool slightly before peeling. It was observed that the cooking time varied slightly between the different cultivars.

Serving procedure

For the evaluation of appearance and texture attributes, the boiled potato samples were cut into 2 halves and a representative sample (7 cm long × 3.5 cm wide) of each accession was served to the assessors in open containers against a white background. For aroma, flavour and taste descriptors, the boiled potato samples were cut into cubes of 2cm × 2cm × 2cm. Two potato cubes approximating 30g were half-filled in 60g plastic vials leaving enough space to allow the odour volatiles to concentrate in the headspace. The potato cubes were allowed to cool to room temperature before being placed in the plastic vials to prevent production of off-odours and flavours that might arise from contact of the hot potato with the plastic containers. Care was also taken to replace used plastic vials by new ones for the next evaluation session. All samples were blind-labelled with random three- digit codes. The order of presentation format was randomised to control positional error which may influence sensory verdicts. Panel members were provided with the score sheet together with the instruction sheet and the agreed ratings for the reference materials. They were advised to drink water between sample evaluations which served as palate cleansers. All samples were evaluated at the Food Science Laboratory, Faculty of Agriculture, University of Mauritius. Since the laboratory did not provide standard sensory facilities, measures were taken to control sources of errors associated with the laboratory environment such as ensuring that assessors are effectively separated, adequate lighting, comfortable seats and no interfering odours. Samples were evaluated in two replicate sessions on two consecutive days on 24 and 25 September 2020 respectively.

Instrumental colour measurement

The flesh colour of boiled potato samples was measured instrumentally with a digital chromameter (Minolta Chroma meter CR-200, Minolta Ltd., Osaka, Japan). The potato samples were cut in half from the bud end to the stem end. Colour measurements were taken at the peripheral and central locations on each potato. Six measurements were taken for each sample. Results were expressed as tristimulus values, L* (lightness, 0 for black, 100 for white), a* (-a* = greenness,

+a* = redness) and b* (-b = blueness, +b = yellowness). The instrument (45°/0° geometry, D25 optical sensor) was calibrated against a standard white reference tile (L* = 92.75, a* = -0.76, b* = -0.07).

Statistical analysis

The IBM SPSS (version 20.0) statistical software was used for sensory quantitative descriptive data analysis. Mean ratings for all sensory descriptors (appearance, texture, aroma, flavour and taste) of the different potato samples and were determined using two- way analysis of variance (ANOVA) which tested the main effect of the replicates, samples, assessors, replicate by assessor and assessor by sample interactions at the 5%, 1% and 0.1% ($P \leq 0.05$, 0.01 and 0.001) level of significance. Instrumental colour measurements were analysed to determine the differences in CIELAB to put punctuation after genotypes mean separation between potato samples (clones) was calculated using the Duncan Multiple Range Test (DMRT). Radar diagrams were generated to visualise and compare the sensory profiles of the different potato samples.

RESULTS AND DISCUSSION

Sensory lexicon

Sensory descriptors, their definitions as well as agreed ratings for reference materials are presented in Table 2. The assessors identified 16 attributes for describing the sensory characteristics of the boiled potato clones. The sensory lexicon comprised of 3 appearance, 5 texture, 4 aroma, 3 flavour, and 1 taste characteristics. Similar results were reported by Ulrich *et al.* (2000) and Bough (2017) when profiling the aroma and flavour of boiled potato. The majority of the descriptors were also present in the sensory lexicon of Sharma *et al.* (2020) comprising of 64 attributes from 55 cultivars of potatoes that were prepared mashed and air- fried. The appearance descriptors of the potato clones were white, cream and yellow. According to Nourian *et al.* (2003a), one of the determining sensory attributes of boiled potato resides in its internal flesh colour which should be creamy white with no anomalous colouration. In line with the above literature, both Spunta and clones therefore possessed the desired flesh colour of table potato varieties.

Sensory profiles of potato clones and Spunta variety

The mean ratings of the 16 sensory descriptors for the six advanced clones compared to the control variety Spunta are presented in Table 3. In terms of appearance, Spunta scored significantly higher for yellow colour (11.07) while all 6 clones obtained significantly higher scores for white ($p \leq 0.05$). The appearance scores indicated that Spunta is a yellow- fleshed variety while the clones are predominantly white- fleshed.

The scores for the texture attributes namely compressibility and stickiness did not differ significantly among clones ($P \leq 0.05$). When compressed with a fork, all potato samples remained compact and homogeneous without disintegrating into pieces. Spunta obtained significantly lower mean sensory ratings for texture characteristics (hardness and coarseness) compared to the remaining clones. All clones obtained low scores for sweet aroma attributes while rancid-like aroma (8.21) was significantly higher in Spunta. However, the non- significant difference in mean sensory ratings for rancid-like flavour between Spunta and the remaining clones could be due to the high between-assessor variations as evidenced by the standard deviation values. Significantly higher ratings for boiled potato aroma (9.12) and boiled potato flavour (8.77) were recorded in Spunta. Although all

Table 2. Definitions and reference materials for sensory descriptors.

Item number	Sensory descriptors	Definitions	Reference materials and agreed ratings*
		Appearance	
1	White	White colour characteristic of white fleshed potato varieties (RHS colour chart, 2001)	Shades of white Boiled potato variety Spunta = 0.0
2	Cream	Cream colour characteristic of white fleshed potato varieties (RHS colour chart, 2001)	Shades of cream Boiled potato variety Spunta = 2.5
3	Yellow	Yellow colour characteristic of yellow fleshed potato varieties (RHS Colour chart, 2001)	Shades of yellow Boiled potato variety Spunta = 10.0
		Texture	
4	Compressibility	Force required to compress the boiled potato using a fork and the degree to which the sample disintegrates (falls into pieces) or remains compact and homogeneous	Boiled potato variety Spunta = 7.5 Boiled sweet potato = 12.5
		Texture (First bite)	
5	Hardness	Force required to bite through one full spoon of the boiled potato sample with incisor teeth and to bring the teeth together (ISO, 2008)	Boiled potato variety Spunta = 2.5 Boiled sweet potato = 0.0
		Texture (Chew down)	
6	Coarseness	Degree of coarse particles in the mouth when one full spoon of the boiled potato is chewed with molar teeth	Boiled potato variety Spunta = 2.5 Boiled sweet potato = 0.0
7	Stickiness	Force required to remove potato sticking to teeth and palate after chewing one full spoon of the boiled potato with molar teeth	Boiled potato variety Spunta = 0.0 Boiled sweet potato = 0.0
8	Dryness	Ease with which the sample is swallowed, amount of moisture released while chewing and the perceived amount of dry particles in the throat after chewing one full spoon of the boiled potato with molar teeth (ISO, 2008)	Boiled potato variety Spunta = 0.0 Boiled sweet potato = 0.0
		Aroma	
9	Sweet	Aroma associated with the perception of sweet substances	Boiled potato variety Spunta = 0.0 Boiled sweet potato = 10.0
10	Boiled Potato	Aroma associated with the flesh of a boiled potato	Boiled potato variety Spunta = 10.0 Boiled sweet potato = 1.5
11	Rancid-like (oxidised/ hydrolysed lipid)	Aroma associated with heated butter	Boiled potato variety Spunta = 10.0 Heated butter = 15.0
12	Mushroom-like	Aroma associated with dried edible mushroom	Boiled potato variety Spunta = 0.0 Fresh mushroom = 12. 5
		Flavour	
13	Potato	The starchy, cooked vegetable- like character associated with the flesh of boiled potato	Boiled potato variety Spunta = 10.0
14	Rancid-like (oxidised/ hydrolysed lipid)	The typical flavour associated with oxidative rancidity of lipid	Boiled potato variety Spunta = 2.5 Boiled sweet potato = 0.0
15	Mushroom-like	The typical flavour associated with dried edible mushroom	Boiled potato variety Spunta = 0.0
		Taste	
16	Sweet	Clean sweet taste of which sucrose is typical	Boiled potato variety Spunta = 2.5 Boiled sweet potato = 3.75

*Perceived intensities were generated on a 0- to 15-cm line scale with 0 = nil and 15 = extreme

Table 3. Mean sensory ratings of 6 advanced potato clones compared to the control variety Spunta (n = 7 assessors)

Sensory Attribute	SED	P-value	Potato genotypes						
			142/161/4	142/161/5	161/142/16	29/5/10	29/5/16	29/5/14	Spunta
					Appearance				
White	0.55	0.000	7.03^{a}±2.81	5.14^{b}±3.43	6.64^{ab}±3.06	7.05^{a}±3.14	4.91^{b}±2.91	6.69^{ab}±2.96	0.45^{b}±0.79
Cream	0.76	0.037	4.00^{ab}±3.75	5.98^{a}±3.74	5.03^{a}±3.23	3.93^{ab}±3.56	4.98^{a}±3.07	3.96^{ab}±2.75	2.23^{b}±1.56
Yellow	0.34	0.000	0.62^{b}±1.45	1.60^{b}±2.56	0.79^{b}±1.51	0.61^{b}±1.36	0.62^{b}±1.36	0.27^{bc}±0.53	11.07^{a}±2.07
					Texture				
Compressibility	0.57	0.779	6.57±2.28	7.50±3.43	6.44±2.67	5.82±2.64	6.66±3.02	5.38±3.82	6.87±2.53
Hardness	0.54	0.006	5.48^{a}±2.77	5.49^{a}±2.30	4.62^{a}±2.12	5.17^{a}±1.50	5.10^{a}±3.46	6.17^{a}±2.55	2.92^{b}±1.52
Coarseness	0.43	0.029	4.14^{a}±2.78	3.84^{a}±2.52	3.75^{a}±1.62	4.28^{a}±2.12	3.57^{a}±1.75	4.14^{a}±2.25	2.32^{b}±0.72
Stickiness	0.13	0.550	0.08±0.33	0.00±0.00	0.08±0.33	0.00±0.05	0.00±0.05	0.00±0.05	0.00±0.05
Dryness	0.68	0.020	5.71^{ab}±3.74	5.48^{b}±2.82	6.21^{ab}±2.25	6.16^{ab}±2.69	7.80^{a}±3.09	4.83^{b}±2.74	7.80^{a}±1.60
					Aroma				
Sweet	0.43	0.000	1.43^{ab}±1.37	0.89^{b}±1.14	2.59^{a}±2.96	0.53^{b}±0.94	1.73^{ab}±1.62	2.89^{a}±2.84	0.44^{b}±0.62
Boiled Potato	0.67	0.001	4.82^{b}±3.53	5.92^{b}±3.15	6.37^{b}±3.25	5.28^{b}±2.45	6.57^{b}±2.70	6.10^{b}±2.40	9.12^{a}±1.24
Mushroom-like	0.71	0.145	2.14^{ab}±1.26	1.16^{b}±0.88	2.05^{ab}±0.63	3.25^{a}±0.55	1.33^{b}±0.37	2.17^{ab}±0.55	0.69^{b}±0.46
Rancid-like	0.98	0.001	2.35^{b}±3.06	4.55^{b}±3.45	4.71^{b}±4.48	3.37^{b}±3.94	4.37^{b}±3.59	2.32^{b}±3.59	8.75^{a}±2.03
					Flavour				
Potato-like	1.61	0.002	5.35^{c}±0.505	7.76^{a}±0.12	6.07^{bc}±0.00	4.94^{c}±0.76	7.12^{ab}±1.29	7.14^{ab}±1.06	8.77^{a}±0.32
Mushroom-like	0.73	0.751	1.87±2.58	1.78±3.12	1.51±2.90	1.87±2.80	1.25±2.59	1.07±2.67	0.36±0.34
Rancid-like	1.03	0.804	4.5±3.64	3.12±3.05	4.23±4.36	2.85±2.47	2.92±3.27	1.78±2.48	3.66±2.79
					Taste				
Sweet	0.39	0.603	1.52±1.78	1.27±1.28	1.62±1.92	0.89±1.33	0.98±1.48	1.25±1.77	0.65±0.83

Mean values in a column with different letters differ significantly (P ≤ 0.05) by DMRT. Sensory scores were rated on a 15 cm line scale where 0 = nil and 15= extreme

clones obtained significantly lower ratings for boiled potato aroma, clones 29/5/14, 29/5/16 and 142/161/5 were similar to Spunta in terms of their perceived intensity for potato-like flavour. There was no significant difference in mean scores between Spunta and the clones for both rancid-like and mushroom-like flavour. Similarly, low sweetness ratings were obtained for all clones and Spunta.

The radar diagrams showed visual differences among the potato clones in terms of appearance and aroma (Fig.3). The scores for yellow colour, boiled potato aroma, rancid- like aroma radiated to the outside of the spider diagrams for Spunta which differentiated it from the advanced potato clones. Nevertheless, the visual sensory profiles revealed that the clones were close to Spunta in terms of texture and flavour.

The non- significant and low scores for sweet aroma and sweet taste among all potato clones corroborate with the findings of Seedfelt *et al.* (2011) and Booysen *et al.* (2013) who found that the aroma descriptors for boiled potato were associated with cooked potato, earthy and buttery notes but not with sweet aroma. In another study by Sharma *et al. (*2020), among 55 potato cultivars evaluated for their sensory characteristics as mashed potato, only nine varieties were found to have sweet aroma. The mild sweetness of the potato

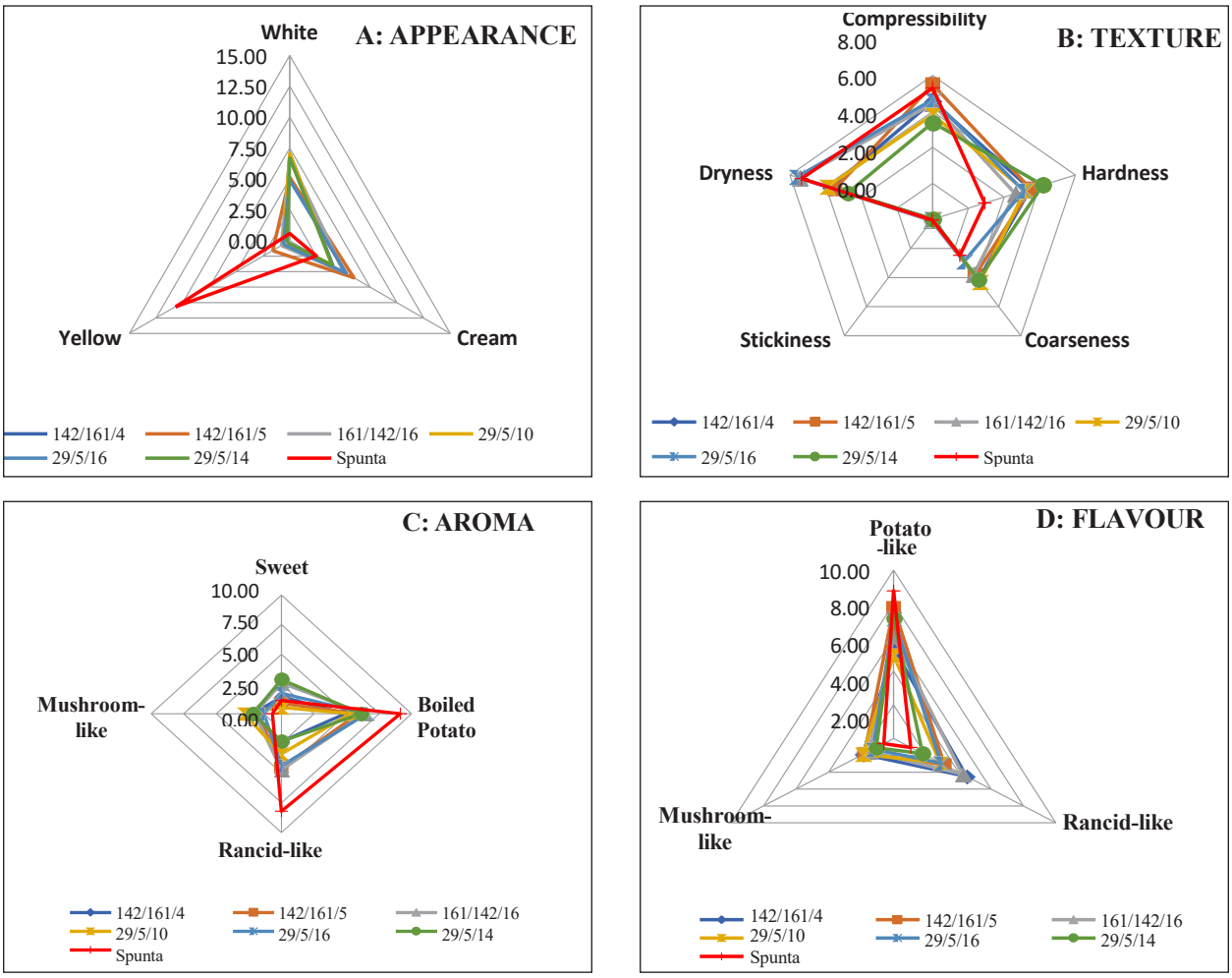

Fig. 3. Radar diagrams of boiled potato genotypes: A: Appearance, B: Texture, C: Aroma, D: Flavour

clones matched the findings of Jansky (2008) who showed that the intensity of sweetness of potato flavour in baked potatoes from a range of market class cultivars (Russets, reds, whites and speciality types) did not exceed 40%.

The low scores obtained for texture attributes (hardness, dryness and stickiness) as well as the moderate perceived intensity ratings for compressibility among potato clones could be attributed to their low tuber dry matter content (Silveria *et al.*, 2020). After compression with a fork, the potato tubers were found to retain their shape without disintegrating apart while imparting a smooth texture during biting and chew down. These observations are in line with the findings of Thybo and Martens (1998), Smith *et al.* (2009), Seefeldt *et al.* (2011) and Pádua *et al.* (2012b) who reported that boiled potato should retain their shape, be moist, creamy and have low mealiness and starch content as their main attributes. Boiled potato aroma and potato-like flavour detected in Spunta as well as the perceived intensity of potato- like flavour in the clones 142/161/5, 29/5/14 and 29/5/16 contribute to desirable sensory characteristics (Whitfield, 1992; Maarse, 1991). Volatiles in boiled potato predominantly include aldehydes, alcohols, ketones, acids, esters, hydrocarbons, amines, furans and sulphur

compounds (Dresow and Bohm, 2009). Among them, methional, diacetyl and alkyl pyrazines are the desirable key odorants reported to exhibit "a cooked/boiled potato aroma" (Ulrich *et al.*, 1998; Lindsay, 1996). Sentence should read: Based on the above arguments, those clones which obtained high mean scores for boiled potato aroma and potato- like flavour should be selected for further sensory profiling studies to improve the market value of potato. Currently, at the FAREI, the local breeding programme is focused on yield, tuber characteristics and disease resistance as key traits while organoleptic characteristics including aroma and flavour are not included as selection criteria because generally most breeding programmes only require the absence of off- flavours (Jansky, 2008). The quantitative descriptive analysis data on aroma and flavour attributes indicated that clones 142/161/5, 29/5/14, 29/5/16 and Spunta have potential for crossing to develop varieties with enhanced flavour characteristics.

Instrumental colour of boiled potato samples

Significant differences in CIELAB colour space values L*, a* and b* ($P \leq 0.05$) were observed among the flesh colour of the boiled potato genotypes after storage at 4- 8 °C overnight (Table 4). All potato clones obtained significantly higher L* values than Spunta except 29/5/10 and 29/5/14. Significantly higher b* values were recorded in Spunta (30.3) and the lowest in 29/5/10 (14.4) and 29/5/14 (14.3). Significantly higher b* values in Spunta corresponded to more yellowness as observed by Pieniazek and Messina (2017) who found that the b* values in cooked Spunta (28.52) is significantly higher than in the cooked freeze- dried form (24.05).

Assessor performance

The results of ANOVA of the mixed model for the 16 attributes are summarized in Table 5. Sources of variation were assessor, sample (genotype), replication and double interactions. The assessors were a significant ($P \leq 0.05$; $P \leq 0.01$; $P \leq 0.001$) source of variation for the majority of the sensory descriptors except for yellow colour, degree of compressibility, rancid-like aroma and rancid –like flavour. However, the replication factor, replication by assessor interaction and replication by sample interaction were not significant except for mushroom- like and rancid like aroma and flavour characteristics. Assessor × sample interaction was not significant for the majority of the sensory descriptors except for coarseness. Significant assessors' effect indicated that variations among assessors may have contributed to observed differences in sensory ratings. Differences amongst assessors' ratings are typical for sensory data (Kreutzmann *et al.*, 2007; Thybo and Martens, 1999). Interestingly, the effect of replication was not significant for most descriptors which implied a low within-assessor variation in repeated sensory profiling sessions. The non- significant assessor × sample interaction gave confidence that overall, the assessors rated the samples

Table 4. Instrumental colour measurements of boiled potato clones compared to the reference Spunta after storage at 4-8°C overnight.

Potato samples	Colour		
	L*	a*	b*
142/161/4	$77.7^{a} \pm 0.43$	$-7.7^{b} \pm 0.66$	$20.6^{b} \pm 3.59$
142/161/5	$78.4^{a} \pm 1.17$	$-7.9^{ab} \pm 0.24$	$19.8^{b} \pm 0.81$
161/142/16	$79.9^{a} \pm 1.19$	$-7.8^{ab} \pm 0.04$	$21.9^{b} \pm 0.42$
29/5/10	$75.5^{b} \pm 0.57$	$-7.2^{c} \pm 0.19$	$14.4^{c} \pm 0.30$
29/5/16	$78.0^{ab} \pm 0.14$	$-7.6^{bc} \pm 0.69$	$19.6^{b} \pm 0.13$
29/5/14	$72.0^{b} \pm 2.32$	$-7.1^{c} \pm 0.38$	$14.3^{c} \pm 1.61$
Spunta	$75.2^{b} \pm 0.59$	$-8.4^{a} \pm 0.10$	$30.3^{a} \pm 1.72$
SE±	0.93	0.25	1.36

Colour measurement: L* (lightness, 0 for black, 100 for white), a* (-a* = greenness, +a* = redness) and b* (-b = blueness, +b = yellowness). Mean values in a column with different letters differ significantly ($P < 0.05$) by DMRT.

Table 5. ANOVA of the mixed model for sensory attributes of boiled potato clones indicating main effects and interaction effects. Assessor, replicate/session, and their interactions were considered as random, while the sample was studied as fixed factor/variable.

Sensory Attribute	P- values					
	Assessor	Sample	Replication	Replication × Assessor	Assessor × Sample	Replicate × Sample
			Colour			
White	0.000***	0.000***	0.672	0.264	0.159	0.366
Cream	0.003**	0.037*	0.631	0.703	0.382	0.108
Yellow	0.348	0.000***	0.738	0.893	0.524	0.678
			Texture			
Compressibility	0.019	0.579	0.463	0.121	0.696	0.254
Hardness	0.004**	0.006**	0.666	0.534	0.145	0.961
Coarseness	0.001**	0.027*	0.363	0.640	0.032*	0.776
Stickiness	0.034*	0.550	0.125	0.034*	0.714	0.548
Dryness	0.000***	0.020*	0.084	0.023*	0.641	0.528
			Aroma			
Sweet	0.006**	0.000***	0.182	0.827	0.268	0.043*
Boiled Potato	0.000***	0.001**	0.634	0.824	0.555	0.577
Mushroom-like	0.000***	0.145	0.427	0.001**	0.964	0.000**
Rancid-like	0.414	0.001**	0.009*	0.779	0.804	0.844
			Flavour			
Potato-like	0.000***	0.002**	0.151	0.211	0.120	0.890
Mushroom-like	0.000***	0.751	0.115	0.000***	0.999	0.550
Rancid-like	0.868	0.572	0.000***	0.104	0.999	0.060
			Taste			
Sweet	0.004**	0.603	0.057	0.492	0.737	0.176

*P ≤ 0.05; **P ≤ 0.01; ***P ≤ 0.001.

in the same direction and with close relative perceived intensities of sensory descriptors. However, the ANOVA data revealed that assessors had difficulty in differentiating between white and cream colour which could be ascribed to low discriminatory/ separating ability (Sipos *et al.,* 2021). In fact, non-conform discrimination is possible because of sensory fatigue or inadequate sensory concentration as the assessors performed the roles of both panelists and students. Thus, in future sensory studies, it is recommended to regularly monitor the performance of selected assessors in order to ensure that they use the scale correctly, score the same product consistently in different replicates as well as attribute intensity evaluation in concertation with other assessors.

CONCLUSION

This study has applied QDA in identifying potato clones for the table potato market. Assessors were effectively trained as measuring instruments to quantify 16 sensory descriptors and develop the sensory profiles of potato clones. Based on texture and flavour attributes, clone 29/5/16 and Spunta were found to be suitable for their culinary use as boiled potato. Furthermore, the assessors further differentiated the variety Spunta from the

remaining clones by the intensity of yellow flesh colour as well as strong boiled potato aroma. Both Spunta and clone 29/5/16 are potential varieties to be used in developing mashed potato product formulations.

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AUTHOR STATEMENT

All authors read, reviewed, agreed and approved the final manuscript

CONFLICT OF INTEREST

None declared

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