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Physicochemical characterisation of some potato varieties grown in the North-West Region of Cameroon and sensory properties of potato food products

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Abstract
The Effect of potato varieties on its physicochemical properties and sensory appraisal of potato food products was conducted in the present study. Seven potato varieties (Banso, Dosa, Jacob 2005, Panamela, Mondial, Belo and Cipira) were collected from farmers of Santa, Mezam Division, North-West Region of Cameroon. They were subjected to physicochemical characterisation including external analyses (length and width, shape, eye-depth and number of eyes) and internal analyses (pH; sugar, dry matter, crude proteins, fat and ash contents; flesh colour and time for enzymatic browning). The sensory attributes of boiled and fried potato evaluated were colour, texture, flavour and overall acceptability. From the results, Banso, Belo and Dosa had deep and the highest number of eyes. Mondial and Jacob 2005 presented the highest length and width, respectively. Banso had the highest ($P<0.05$) pH value and Jacob 2005 the highest ($P<0.05$) dry matter which was ≤17.9 %. Cipira, Banso and Panamela significantly ($P<0.05$) showed high ash, crude proteins and fat contents, respectively. Jacob 2005 was whitish and other varieties creamy. Jacob 2005 and Cipira potato indicated rapid browning. Accordingly, Jacob 2005, Panamela, Mondial, and Cipira are mostly recommended for processing although Cipira, Jacob 2005 and Mondial are appropriate for French fries while Banso, Dosa, Panamela, Belo and Cipira are for crisps. Sensory evaluation scores revealed that Cipira and Dosa were the most preferred boiled and fried, respectively.

Keywords: Potato varieties; physicochemical characterisation; sensory evaluation; boiled potato; fried potato

Introduction

Potato (*Solanum tuberosum* L.) is the third most important food crop in the world after rice and wheat [1]. In addition to its culinary versatility, potato has the advantage of being a low-cost product, so it is available to all social classes [2]. It represents nowadays the most important food in terms of volume of consumption and economic value. Since the early 1960s, the growth in potato production area has rapidly overtaken all other food crops in developing countries and potato has become a fundamental element in food security for millions of people across South America, Africa, and Asia [3].

In Cameroon, potato, a non-traditional basic food, is playing an important role towards food security and represents one of the most commercial foods. Thus, it is an income generating crop for most farmers. Potato is also a good source of dietary energy and some micronutrients, and its protein content is very high in comparison with other roots and tubers [4]. It is an excellent source of vitamin C; a good source of potassium and vitamin B6; low in sodium and cholesterol and fat-free [5]. Due to its high vitamin C content, it promotes iron absorption [4]. In addition to vitamin C, potato is also an excellent source of other biologically active substances such as polyphenols and flavonoids, which are commonly described as antioxidants [6; 7].

With population doubling every 25 years and urbanization continuing to increase yearly, feeding habits are changing in favour of easy-to-prepare foods [8]. Potato is a versatile, carbohydrate rich food highly popular worldwide and prepared and served in a variety of ways. Also, as part of the trend toward greater consumption of “convenience foods”, demand for fried potatoes is increasing [4]. However, the suitability of potatoes for processing is dependent on the tuber quality which takes into consideration both internal and external parameters [9].

Processing of potato is then of importance due to its high perishability and post-harvest losses during harvesting season. In Cameroon, the North West Region represents one of the highest production zones of the commodity beside the West region. Different varieties are available and are local, imported, improved or developed by the Institute of Agricultural Research for Development (IRAD). Processing will not only increase the shelf life, but it will also increase

income of farmers by value addition and subsequently contribute to reduce poverty. However it is judicious to determine which potato variety is convenient for which potato product for the satisfaction of the consumer.

Hence, the aim of this study was to evaluate the suitability of potato varieties grown in the North West Region of Cameroon to processing techniques, through physicochemical characterisation and sensory evaluation of some potato food products in order to identify their best forms of transformation, sales and consumption.

Material and methods

Sample collection

This study was done by using seven potato varieties obtained from farmers of Santa Municipality (05°51.382' N; 010°10.500' E), in Mezam Division, North West Region of Cameroon. Santa locality has an average annual rainfall of 2135 mm and an average temperature of 18.8 °C with penevoluted ferralitic and Aliatic soils.

The full mature potato varieties (table 1) were purchased during the raining season, in the months of September and October. They were obtained from farmers after harvesting and transported in bags to the laboratory for analysis. Each variety was obtained from one, two or three farmers according to its availability.

Table 1: Varieties and number of samples collected

N°.	Name of variety	Class of variety	number of sample collected
1	Banso	Local	03
2	Belo	Local	03
3	Cipira	IRAD Improved	03
4	Dosa	Imported	03
5	Jacob 2005	IRAD Improved	02
6	Mondial	Imported	01
7	Panamela	Imported	03

Determination of external parameters

The external parameters included tuber size (length and width), shape, eye-depth and number of eyes.

Tuber size: The tuber size was measured by using 10 potato tubers randomly selected from each farmer's lot. It was done using a Calliper. The length was obtained by the measurement of the distance between the apical end to the stolon end of the tuber while the width (diameter) was measured midway the length on a horizontal axis.

Tuber shape: The tuber shape was determined by calculating the index value (I.V.) of tuber as described by Ekin [10]. I.V. = L/Wx100 (L: length of the tuber; W: width of the tuber). The shape is round when IV <109; short-oval when 110≤IV≤129; oval when 130≤IV≤149; oval long when 150≤IV≤169 and long when 170≤IV≤199.

Number of eyes and eye depth: The number of eyes of potato tubers was obtained by enumeration and the eye-depth by observation. This was done with a team of five researchers.

Determination of internal parameters: The internal parameters included the pH, the sugar content, the dry matter (total solids) content, the crude proteins content, the fat content and the ash content. Also, the flesh colour was observed and the time for enzymatic browning was taken.

For the determination of pH, sugar content, dry matter (total solids), crude proteins, fat and ash contents, 10 potato tubers were randomly selected from each lot and mixed per variety. Each potato sample (variety) was analysed in triplicate.

Determination of sugar content (°Brix)

The juice extracted from the pulp of grated potato tubers was used for the determination of sugar content. Two droplets of juice at 20 °C were placed on the prism of an Eclipse refractometer and the value read on the scale of the instrument was recorded.

Determination of pulp pH [11]

50g of potato flesh was ground with 100 mL of distilled water. The pH value was measured by using a digital pH-meter (HANNA pHep).

Determination of dry matter (DM) content [12]

Potato samples were washed with potable water, finely peeled and sliced into small pieces. Stainless steel dish was washed and dried in the oven at 105 °C for 1 hour, cooled in a desiccator for 30 minutes and weighed (W0). 20 g (W1) of sample (potato variety) were weighed into a stainless steel dish and dried in the oven at 105 °C to constant weight (24 hours). It was then removed and cooled in a desiccator for 1 hour and the weight of the dish and dried sample (W2) was recorded. The dry matter was calculated using the formula:

$$\text{Dry matter (\%)} = \frac{(W2 - W0) \times 100}{W1}$$

Determination of ash content [12]

Potato sample was washed with potable water, finely peeled and sliced into small pieces. Stainless steel dish was washed and dried in the oven at 105 °C for 1 hour, cooled in a desiccator for 30 minutes and weighed (W0). 5g (W1) of dry sample (potato variety) were weighed into a stainless steel dish and put in a Muffle furnace at 550 °C for 6 hours. It was then removed, cooled in a desiccator for 1 hour and the weight of dish and ash (W2) was recorded. The ash content was calculated using the formula:

$$\text{Ash content (\% DM)} = \frac{(W2 - W0) \times 100}{W1}$$

Determination of fat content [12]

The fat content was obtained using Soxhlet extraction. 5 g (W1) of dry sample were tied in the filter paper and placed in an extraction thimble (cartridge cellulose). The whole setup was loaded into the main chamber of the Soxhlet extractor. The Soxhlet extractor is fixed onto a flask previously washed, dried in the oven and weighed (W0). The main chamber was then filled with Hexane (extractor solvent) and half volume added after siphoning in the flask. After, the Soxhlet extractor was then connected to a condenser. The solvent was heated for 6 h to reflux. After extraction, the solvent was removed by heating the flask at low temperature (40 °C). The flask containing only the fat was then cooled in desiccator and weighed (W2). The fat content was obtained as follows:

$$\text{Fat content (\% DM)} = \frac{(W2 - W0) \times 100}{W1}$$

Determination of crude proteins content [1]

The crude proteins content was obtained by Kjeldahl method. 1 g (W0) of dry sample was put in the digestive tuber, 20 ml of concentrated sulphuric acid (98%) was added and the whole heated for 3 h in presence of catalyst. After the digested sample was diluted with distilled water to 100 ml and recuperated in 50 ml of boric acid (4%) after distillation in the presence of 1 M NaOH using Kjeldahl distiller. It was then titrated with chloric acid 0.25 M. The crude protein content is given according to the formula:

Crude proteins (% DM) = V x C_N x 14.01 x 6.25 /W0

V: Titration volume (ml); C_N: Chloric acid concentration

Determination of Flesh colour and Rate of enzymatic browning

Ten tubers from each variety were cut into two halves each and observation was ensured by 5 researchers. The tuber flesh colour was recorded and the enzymatic browning (or darkening of cut tuber) rate was measured as the time taken by the sliced potato to have a prominent colour change.

Sensory evaluation of processed products

Sensory evaluation was performed on boiled potatoes and potato fries. Sample (potato variety) was washed several times with potable water and the quantity weighed (W0). It was then finely peeled using a potato peeler and the weight (W1) of the peels recorded. The percentage of losses (peelings) was calculated using the formula:

$$\text{Potato peel loss (\%)} = \frac{W1}{W0} X\ 100$$

W0: Weight of unpeeled potatoes

W1: Weight of peels

The boiling was done following procedure in previous study [13]. After potato sample was peeled, it was washed with portable water, wrapped in the plastic wrap and boiled until ready. It was considered ready when a tooth pick could penetrate into the flesh. The processing steps of boiled potatoes are given in figure 1.

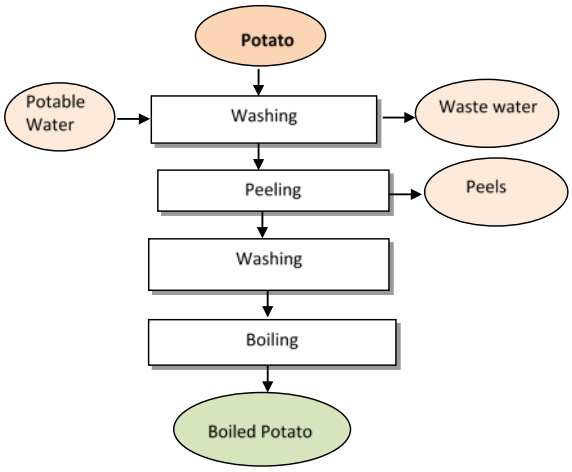

Fig 1: Processing steps of boiled potatoes

The potato fries were obtained following the steps presented in figure 2 [13]. After peeling and washing, potato tubers were sliced using a potato cutter and fried in an electric deep potato fryer containing oil (Mayor) to the maximum graduation. Frying was done at 160-170 °C for 10-15 min. After frying, the sample was put in the foil paper prior to sensory evaluation.

Sensory evaluation of boiled and fried potatoes were done using a 9-point hedonic scale with categories from like extremely (9) to dislike extremely (1) using a panel of 15 pannelists consumers of potato processed products, aged between 20 and 60 years and made up of students, workers, researchers and technicians. Sensory attributes assessed were colour, texture, flavour and overall acceptability. Samples were served simultaneously to panellist with potable water for rinsing of mouth between samples. Before the sensory evaluation, panellists were sensitised.

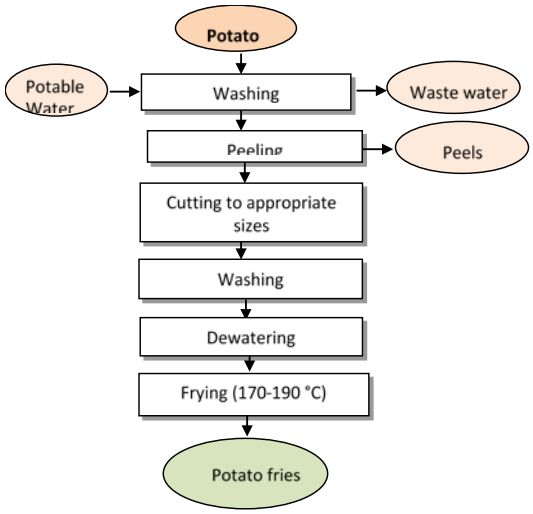

Fig 2: Processing steps of potato fries preparation

Statistical analysis

The data collected were expressed as Mean ± SD. Data from the physicochemical properties and sensory evaluation were subjected to Analysis of Variance (ANOVA) using the Statgraphics Plus, version 5.0 statistical package. The means obtained were separated using the Fischer Test (P≤0.05).

Results and discussion

External parameters

Length and width of potato tubers

From the results, the length varied from 9.84 cm for Mondial potato variety to 5.27 cm for Dosa potato variety (figure 3). The values obtained seemed to be slightly higher compared to that of Banso, Belo, Dosa and Jacob 2005 potato varieties but similar to that of Cipira and Mondial potato varieties revealed by previous findings [13].

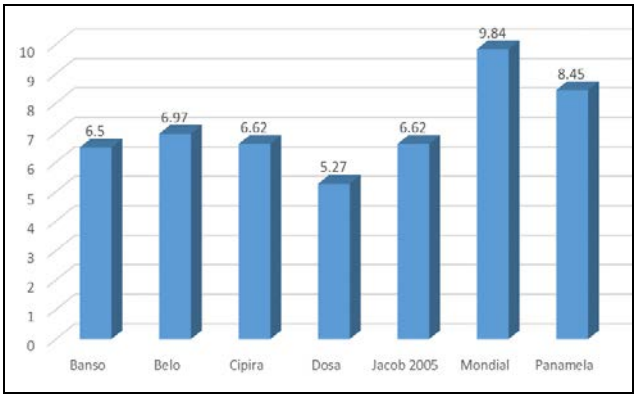

Fig 3: Average length of potato tubers

The width of studied potato varieties are presented in figure 4. The width ranged between 5.46 cm for Jacob 2005 potato variety and 4.4 cm for Dosa variety. The width indicated by Jacob 2005 and Mondial variety appeared higher compared to previous results [13]. However, concerning Banso, Belo, Cipira and Dosa varieties, results were similar.

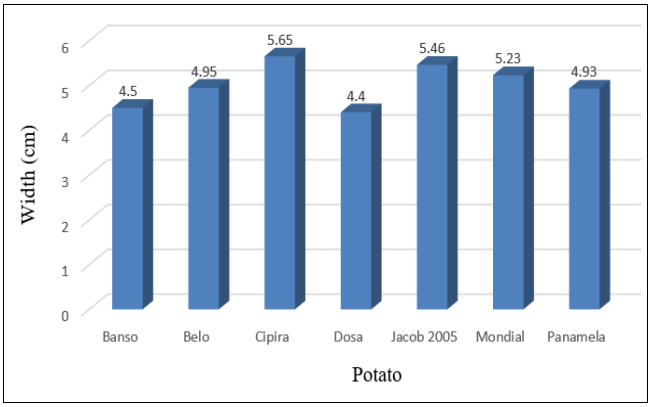

Fig 4: Average width of potato tubers

For industries processing potatoes, tubers larger than 5 cm are ideal for French fries while tubers having 4 to 5 cm are ideal for crisps [9, 14]. Therefore, considering the width of tubers obtained, Cipira, Jacob 2005 and Mondial are more suitable for French fries while the other varieties are suitable for crisps.

Index value, tuber's shape, number of eyes and eye-depth

The tuber's shape of Banso and Belo varieties were Oval, while that of Cipira, Dosa and Jacob 2005 are short oval and that of Mondial and Panamela were long according to the index value obtained (table 2).

Banso, Belo and Dosa indicated the highest number of eyes (9-11) while Panamela, Jacob 2005 and Mondial (5-7) had the lowest. Banso, Belo and Dosa had deep eyes as compared to the other varieties which showed shallow eyes. Potato varieties with shallow eyes are mostly preferred for processing due to their supposed low peeling losses [9].

Table 2: Index value, tuber's shape, number of eyes and eye-depth of potato tubers

Potato variety	Index value	Tuber's shape	Number of eyes	Eye-depth
Banso	144.44	Oval	10-11	Deep
Belo	140.8	Oval	9-10	Deep
Cipira	117.16	short-oval	7-8	Shallow
Dosa	119.77	short-oval	10-11	Deep
Jacob 2005	121.24	short-oval	6-7	Shallow
Mondial	188.14	Long	6-7	Shallow
Panamela	171.39	Long	5-6	Shallow

Internal parameters

Physicochemical properties

The Banso potato variety indicated significantly (P<0.05) the highest value (6.35±0.05) of pH while Mondial variety had significantly (P<0.05) the lowest value (5.92±0.06) (table 3). Cipira, Belo, Dosa and Jacob 2005 varieties revealed similar (P>0.05) pH values which were significantly (P<0.05) lower compared to that of Panamela variety (6.19±0.04). The pH value obtained in the present study appeared to be lower than that of previous study [13] for the same variety of potato.

Cipira potato variety had the highest value of sugar content (4.83±0.28 °Brix). This value was not significantly (P>0.05) different to that of Belo (4.33±0.57 °Brix) and that of Dosa (4.66±0.28 °Brix). For the same sample studied, the value of sugar content seemed to be lower than that of previous findings [13]. With respect to Mondial variety, the sugar content observed is apparently lower compared to that revealed by previous studies [11, 15].

Table 3: Physicochemical properties (Mean±SD) of potato varieties

Potato variety	pH	Sugar (° Brix)	DM (% FW)	CP (% DM)	Fat (% DM)	Ash (% DM)
Banso	6.35±0.05a	4.16±0.28bc	15.86±0.57b	9.28±0.10a	0.90±0.00e	2.08±0.09e
Belo	6.02±0.01c	4.33±0.57abc	16.34±0.59b	8.86±0.10b	1.18±0.00c	2.08±0.09e
Cipira	6.04±0.03c	4.83±0.28a	15.65±0.55b	7.59±0.08d	0.36±0.00g	3.58±0.00a
Dosa	6.07±0.02c	4.66±0.28ab	15.99±0.59b	8.93±0.09b	1.35±0.00b	2.53±0.00c
Jacob 2005	6.02±0.01c	4.00±0.00c	17.49±0.33a	7.50±0.08d	1.08±0.00d	2.80±0.09b
Mondial	5.92±0.06d	4.16±0.28bc	14.79±0.35c	9.01±0.01b	0.63±0.00f	2.80±0.09b
Panamela	6.19±0.04b	4.16±0.28bc	15.78±0.59b	8.08±0.01c	1.45±0.00a	2.26±0.09d

(a,b, c): Values with the same letter in the same column are not significant different (P>0.05); FW : Fresh Weight ; DM : Dry Matter ; CP : Crude Proteins.

The dry matter values ranged between 14.79±0.35% (Mondial variety) and 17.49±0.33% (Jacob 2005 variety). Jacob 2005 had significantly (P<0.05) the highest value and Mondial the lowest (P<0.05). Other potato varieties presented similar (P>0.05) dry matter values. These values were generally lower than those obtained by previous authors [13]. From the values obtained, all the potato varieties are not suitable for fries and crisps because they are less than 20%. In fact, a level of dry matter content of potato tuber above 20% is best for fries and crisps due to the high product yield and profitability, improvement of crispness of the fried products and prevention of excessive fat absorption during frying [9; 10]. They are all better for salads because of their dry matter lower than 17.9% [11]. This result is not consistent with previous results [13] who indicated that Cipira, Banso and Belo varieties with high dry matter (>20) are good for frying, mashing and roasting whereas Dosa and Jacob 2005 varieties with intermediate dry matter content (between 18 and 19.9 %) will be preferred for mashing and roasting.

Cipira variety with 3.58±0.00% of dry matter significantly (P<0.05) indicated the high value of ash content and the lowest (P<0.05) value was obtained by Banso and Belo varieties (2.08% of dry matter). Concerning crude proteins, Banso had significantly (P<0.05) the highest amount (9.28±0.10 % of dry matter) while Jacob 2005 and Cipira showed significantly (P<0.05) the lowest amount (7.50±0.08% and 7.59±0.08% of dry matter, respectively).

Panamela variety revealed significantly (P<0.05) a high value of fat content (1.45% of dry matter) and Cipira the lowest (P<0.05) value (0.36% of dry matter). Also, the fat content was decreasing significantly (P<0.05) according to the following order respectively: Panamela, Dosa, Belo, Jacob 2005, Banso, Mondial and Cipira.

The physicochemical properties varied from one variety to another in general and this could be attributed to their different genome. However, the dry matter content and the ash content of the present study was lower than values obtained by previous authors who worked on five potato varieties (Saturna, Hermes, Raja, Rosalind and Courage) in Poland [16] while the protein contents was similar for both studies. Regarding fat content, values obtained appeared lower compare to that of Hermes and Raja potato varieties but similar to results revealed by other varieties. These differences observed could be attributed to the genetic material (genome) of those respective varieties in addition to other factors including the type of soil, the climate or season and the agricultural practices. Results of the present study contrast those of previous studies which looked at the same potato varieties obtained from the same area (Santa, Mezam Division, North West Region, Cameroon) [13]. The difference observed could be attributed to the season of study. Potato samples in the previous study were collected in dry season while in the present study, samples were collected in raining season.

Flesh colour and Rate of enzymatic browning

As indicated by previous results. [13], except Jacob 2005 which was whitish, other potato varieties were creamy. Jacob 2005 and Cipira potato varieties indicated a browning less than 30 min after cutting in two halves and exposure to sunlight while colour of other potato varieties remained unchanged after more than 90 minutes. This result is not consistent with that previously observed [13] in general and may be explained by the low intensity of sunlight radiations considering that the work was done in the raining season. Also, the tuber could have been less damaged and the browning could be as result of the mechanical damages of the tubers from rough handling during and/or after harvest.

Peeling losses

Dosa and Banso potato varieties indicated the highest percentage of peeling losses (19.13% and 17.58%, respectively (figure 5). This could be related to their deep eyes. On the other hand, Belo and Cipira with respectively 11.5% and 12.38% had the lowest percentages. Belo had low peeling losses but had deep eyes and this result could be associated with large surface area compared to Dosa and Banso.

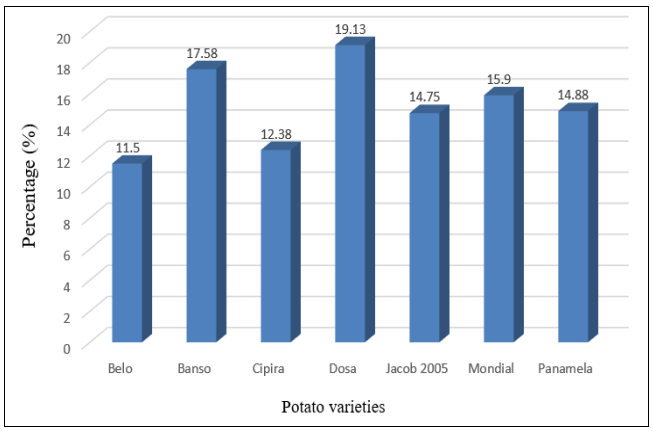

Fig 5: Peeling losses (%) of potato tubers

Sensory evaluation scores of potato products

Boiled potato

By boiling the potato tubers, Mondial indicated the highest score with respect to the colour (table 4). The score obtained was significantly (P<0.05) different compared to that of Jacob 2005 which had the lowest value. Also, a significant (P<0.05) difference was observed between colour of Jacob 2005 compared to that of Panamela and Cipira.

Panellists attributed the highest score concerning the texture of boiled potato to Cipira. Cipira score was significantly (P<0.05) different to that of Panamela, Jacob 2005 and Dosa. Panamela obtained the lowest score which were significantly (P<0.05) lower to that of Belo also.

The flavour of boiled potato was highly appreciated with Banso variety. This level of appreciation was significantly (P<0.05) different to that of Dosa, Jacob 2005 and Panamela (lowest score) which were not significantly (P>0.05) different.

In all sensory attributes, Cipira was more appreciated by the panellists. overall, it was equally more appreciated. Its level of acceptability was significantly (P<0.05) different compared to Dosa, Jacob 2005 and Panamela. Panamela and Jacob 2005 were less appreciated and had the same score which was not significantly (P>0.05) different with that of Dosa and Mondial.

Table 4: Sensory evaluation scores (Mean±SD) of boiled potato

Potato variety	Colour	Texture	Flavour	Overall acceptability
Banso	6.10±1.46ab	5.80±2.21abc	6.66±1.67a	6.4±1.76ab
Belo	6.00±1.89ab	6.33±1.71ab	6.20±1.65ab	6.06±2.28abc
Cipira	6.86±1.55a	6.66±2.32a	6.13±2.23ab	6.60±2.32a
Dosa	6.00±1.92ab	4.86±2.74bc	4.46±2.26c	5.00±2.23bc
Jacob 2005	5.33±2.54b	5.26±2.08bc	4.73±2.40bc	4.60±2.35c
Mondial	7.13±2.06a	5.53±2.56abc	5.60±2.29abc	6.20±2.14ab
Panamela	7.06±2.03a	4.46±2.66c	4.26±2.54c	4.60±2.16c

(a,b, c): Values with the same letter in the same column are not significant different (P>0.05)

Potato fries

Cipira variety had the highest score concerning colour of potato fries which was significantly (P<0.05) different with that of Banso, Belo, Jacob 2005 and Mondial (table 5). Belo and Jacob 2005 presented the lowest scores which were not significantly (P>0.05) different with that of Mondial and Banso.

Table 5: Sensory evaluation scores (Mean±SD) of potato fries

Potato variety	Colour	Texture	Flavour	Overall acceptability
Banso	5.78±1.84bc	6.00±1.79abc	6.28±1.38ab	6.35±1.73abc
Belo	5.14±1.95c	6.07±1.54abc	6.21±1.47ab	6.21±1.42abc
Cipira	7.57±1.15a	6.21±1.71ab	6.64±1.69ab	6.71±1.49ab
Dosa	6.92±1.85ab	6.57±1.28a	6.92±1.26a	7.00±1.10a
Jacob 2005	5.64±1.82c	5.64±1/64abc	5.64±1.59bc	5.71±1.72bc
Mondial	6.28±1.63bc	4.92±1.85c	4.85±2.17c	5.14±1.95c
Panamela	7.64±0.92a	5.28±1.63bc	5.42±2.06bc	5.85±1.83abc

(a,b, c): Values with the same letter in the same column are not significant different (P>0.05)

The texture of Dosa was highly preferred and significantly (P<0.05) different with the level of preference of Mondial and Panamela. Mondial was less appreciated with respect to texture but similarly (P>0.05) to Panamela, Jacob 2005, Belo and Banso.

Panel members attributed the highest score to Dosa for flavour of potato fries. This score was significantly (P<0.05) different to that of Jacob, Mondial and Panamela. These three potato varieties obtained the lowest scores which were all not different (P>0.05).

The most appreciated potato fries by panellists was Dosa which obtained the highest score. This score was significantly (P<0.05) different to that of Jacob 2005 and Mondial. These varieties were less appreciated in all sensory attributes.

Conclusion

From the results of this study, Jacob 2005, Panamela, Mondial, and Cipira potato varieties are most suitable for processing. Also, Cipira, Jacob 2005 and Mondial varieties are more suitable for French fries while the other varieties are more suitable for crisps on the one hand, and on the other hand, all are suitable for salads. All the potato varieties had a pH value closed to 6 and sugar content between 4 and 5 °Brix. Jacob 2005, Cipira, Panamela and Banso have the highest amount of dry matter, ash, fat and crude proteins contents. From the sensory evaluation, Cipira, Belo, Banso and Mondial are suitable for boiled potato while Dosa, Cipira, Banso and Belo are most suitable for potato fries.

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Conflict of interest

There is no conflict of interest

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