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Effect of Starch Type on the Physicochemical and Textural Properties of Beef Patties Formulated with Local Spices

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Abstract This study was aimed at evaluating the effect of local potato and cassava starch on the proximate compositions, physicochemical and textural properties of beef patties. The control patty ($P_{control}$) was prepared with commercial Leader price™ potato starch incorporated at 50g/kg of ground meat, while other patties were formulated with starch from two local potatoes (*Sipiera* and *Tselefou*) and tree local cassava varieties (*2524*, *4115* and *Seedling*) during which 20, 30, 40 and 50g starch /kg of ground meat was used.The results showed that moisture content varied according to starch type and starch quantity for both raw and cooked patties. Water contents of cooked patties were lower than their corresponding raw ones. The same trend was not observed for protein and fat contents of cooked patties. Starch content significantly affected the water holding capacity of raw patties ($P<0.05$) and for cooked patties, cooking yield was improved ($P<0.05$) at the lowest starch incorporation rate (20%) irrespective of the starch type. Patty prepared with Seedling starch at incorporation rate of 40g/kg of batter (*PS40*) is the most similar to the control one.

Keywords: *Beef patties, potato starch, cassava starch, physicochemical and textural properties*

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1. Introduction

The use of extenders/binders/fillers in the elaboration of food products is on the rise because the latter presents the advantage of minimising product cost and improving or at least maintaining nutritional and sensory qualities of the final products [1]. The increasing demand for better quality and healthy meat products has also stimulated the use of new non-meat components. These non-meat components of natural or synthetic origin, known under the name of hydrocolloids or structuring additions, are introduced during processing and preservation of meat products [2]. Other non-meat additives tested as binders/extenders include: soya beans in meat products [3,4,5], faba beans, lentils, lupin and chickpeas in beef sausages [6], wheat flour in chicken nuggets [7], defatted sunflower meal in beef patties [8], cowpea and peanut flours in chicken nuggets [9,10]. Studies on functionality of various fillers including corn starch [11,12], rapeseed and mustard [13] as extenders in meat emulsions have also been reported. Starches are multifunctional food ingredients. They have many functional applications, including adhesion, binding, emulsion stabilisation, gelling and moisture retention [14]. Sunflower protein, corn germ flour and wild rice starches are used as binders and extenders in comminuted meat products to perform three basic functions: fat emulsification, water retention and to enhance the structure of meat products [5]. Readily available native starch could be a potentially cheap substitute for the higher priced modified starch and gums which are in common use [15,16]. Irish potatoes (*Solanum tuberosum*) and cassava (*Manihote sculanta*) tubers are abundant in Central Africa and other tropical areas and could serve as an economical source for starch. This is exemplified by the works of Mbougueng *et al.* [17] which revealed that some local native starches have physicochemical, functional and rheological properties similar to that of modified potato starch currently used as binders in meat products. In the present study, an investigation of the suitability of replacing commercial modified potato starch with native starch from local tubers in the production of beef patties was evaluated.

2. Materials and Methods

2.1. Materials

The *Sipiera* and *Tselefou* cultivars of Irish potato (*Solanum tuberosum*) were purchased at a local market while the *2425*, *4115* and *Seedling* cultivars of Cassava (*Manihote sculanta* Crutz) were supplied by IRAD (Institute of Agricultural Research for Development) of Ngaoundere-Cameroon. These tubers were used at their commercial maturity, 6 months for potato and 12 for cassava. The control used in this study was the commercial Leader price™ potato starch.

Beef semi-membranous muscle (top round), udder fats and liver were obtained from an approved European abattoir (SOCOPA Mircourt slaughter-house: Nancy-France) using industrial slaughtering techniques. These samples were trimmed off all visible extra-muscular fat and connective tissue before storage at - 4°C for 72 hours. A formulation of local spices made up of fruit mixtures (*Hua gabonii*, *Xylopiaa ethiopica*, *Monodora myristica*) and the pulp of the fruit wings of *Tetrapleura tetraptera* [18] was used in the present study. For the exact composition of this spice mixtures contact the department of Food Science and Nutrition, University of Ngaoundere-Cameroon.

2.2. Methods

Starches used in this study were those extracted and characterised by Mbougueng *et al [17]*.

2.2.1. Native Starch Production

Starch extraction was carried out by the method of Alves *et al.* [19] with a slight modification. A total of 10 kg of tubers and roots were used in this study. All impurities and damaged tubers and roots were discarded. The remaining tubers and roots were first peeled, washed with distilled water, cut into small sizes and then chopped with a cutter (Manurhin, 03300 Cusset, n°426, France). The resulting product was mixed with distilled water. Fibres were separated by sieving through a 170-mesh screen. After washing several times, the starch obtained was oven dried at 45°C. Dried samples were then ground by using a Hobart mixer (Model 32BL79, New Hartford, CT 0657, USA).

2.2.2. Product Manufacture

Prior to processing, beef fats (udder) were boiled in water for 15min. and ground with liver and muscle meat through a 2mm plate. The ground meat, liver, beef fat, 2% sodium nitrate and locally formulated spices were thoroughly mixed for 5min. Six groups of patties were prepared and tested.

1) The control patty, containing 50g Leader price™ potato starch/kg ground meat ($P_{Control}$= PFPC).

2) The patties formulated with 20, 30, 40 and 50 g of *Sipiera* potato starch/kg of ground meat were designated, PSi_{20}, PSi_{30}, PSi_{40} andPSi_{50} respectively.

3) The patties formulated with 20, 30, 40 and 50 g of *Tselefou* potatoes starch/kg of ground meat were designated, PT20, PT_{30}, PT_{40} andPT_{50} respectively.

4) The patties formulated with 20, 30, 40 and 50 g of *2425* cassava starch/kg of ground meat were designated, PV_{20}, PV_{30}, PV_{40} andPV_{50} respectively.

5) The patties formulated with 20, 30, 40 and 50 g of *4115* cassava starch/kg of ground meat were designated, PQ_{20}, PQ_{30}, PQ_{40} andPQ_{50} respectively.

6) The patties formulated with 20, 30, 40 and 50 g of *Seedling* cassava starch/kg of ground meat were designated, PS_{20}, PS_{30}, PS_{40} and PS_{50} respectively.

Beef patties were cooked at 90°C in an oven (Memmert, UL 40, West Germany) to an internal temperature of 70°C. Cooked products were allowed to cool down at room temperature (22-25°C) for 30min. Cooled patties were cut into 25-30g portions, wrapped with aluminium foil and stored at 4°C prior to analyses.

2.2.3. Proximate Analysis of Patties

Moisture, protein, fat and ash contents were determined on raw and cooked products using AOAC methods [20]. Moisture was determined as weight loss of 3g sample after drying for 18h at 102°C. Crude protein was analysed by the micro Kjedahl method (Nx6.25). Fat was determined by weight loss after 16h extraction in a soxhlet apparatus with petroleum ether and ash by incineration of 3g sample at 550°C until a light grey ash result.

2.2.4. pH Determination

10 g of raw and cooked patties were homogenised with 90 ml of distilled water and the pH was determined with a pH-meter (Eutech Cybernetics, Cyberscan 1000, Singapore) [21].

2.2.5. Water Holding Capacity

The Tsai & Ockerman [22] press technique was used with some modification to measure the water holding capacity (WHC) of the raw patties. A sample (0.5g) was placed between 2 sheets of filter paper (Whatman n°1, stored over saturated KCL) which was placed between two Plexiglas sheets and pressed for 30minutes under 1kg load. The area of pressed meat and a spread juice was measured and the water holding capacity was calculated as follows:

$$\%FW = \frac{(Surface\ area - meat\ area)\left(mm^2\right)(6.11)}{(Total\ moisture\ in\ meat\ sample)(mg)} X100$$

%FW = % Free Water

WHC = 100 – %F W.

2.2.6. Cooking Loss

After formulating patties and placing them in mould of known weight, the filled moulds were weighed and then place in the oven for baking. At the end of the baking period, they were left to cool and then their weighed again.

$$\text{Cooking loss} = \frac{Raw\ weight - Cooked\ weight}{Raw\ weight}.$$

2.2.7. TBA Values

The degree of lipid oxidation of the raw and cooked beef patties was determined by the 2- thiobarbituric acid (TBA) cold extraction method, described by Wite *et al.* [23] was used. The results are expressed as mg malonaldehyde /kg of patty.

2.2.8. Color Measurement

Each patty sample was evaluated using a colorimeter (Lovibond RT Colour Measurement Kit V2.28) with a window of observation of 10° and one source of D65 light, the apparatus was gauged with a standard white plate (Lovibond RT100 N 319452) whose co-ordinates of color are: L* = 93,87, a* = 0,18 and b* = 2,71. L values range from 100 (white) to 0 (black), a values range from +a (green) to –a (red), and b values range from +b (yellow) to –b (blue). Average of the readings were computed and reported. Each result is the average of three determinations [24].

2.2.9. Texture Analysis

A texture profile analysis was applied to the cooked products based on a method described by Bourne [25]. Tree cores (diameter = 2.2 cm; height = 2cm) were cut from each cooked patty and were axially compressed to 50% of their original height in a two-cycle compression test using an Instron Universal Testing Machine (Model 4464, Instron Engineering Corp., Canton, MA). Determinations were performed at room temperature using tree replicates of cooked patties per treatment. Force-time deformation curves were obtained using a 5 kN load cell applied at a crosshead speed of 50mm/ min. The attributes reported are: hardness (N), cohesiveness (dimensionless), springiness (mm) and chewiness (Nxmm).

2.2.10. Statistical Analysis

The effect of each treatment was analyzed from the different preparations. Data were subjected to analysis of variance and the differences among means were obtained using Duncan's multiple range test (significance $p<0.05$) using the Statgraphics plus 5.0software.

3. Results and discussion

The starches used in this study were those extracted and characterised (Amylose, Phosphorus, Colour, Paste clarity, Particle size distribution, Scanning electron microscopy, Thermal properties, Swelling power, oil and water absorption capacity) by Mbougueng *et al* [17].

3.1. Proximate Composition of Raw and Cooked Patties

The results of proximate composition of raw and cooked patties are shown respectively on Table 1 and Table 2.

Table 1. Effect of starch types and starch rate on physicochemical properties of raw patties (%FM)

	Rates	$P_{Control}$	PSi	PT	PV	PQ	PS
Moisture	20		67.72±0.04^{kl}	67.55±0.07^{jkl}	67.42±0.48^{ijkl}	67.75±0.11^{kl}	67.30±0.08^{ijk}
	30	/	67.88±1.22^{l}	67.02±0.49^{ghi}	66.71±0.22^{fgh}	66.14±0.35^{bcde}	65.94±0.41^{abc}
	40		67.19±0.21^{hij}	66.75±0.46^{fgh}	66.59±0.15^{efg}	66.53±0.22^{defg}	65.68±0.19^{ab}
	50	66.03±0.60^{bc}	66.06±0.35^{bcd}	65.81±0.07^{ab}	66.43±0.29^{cdef}	65.54±0.61^{a}	66.62±0.37^{efg}
Protein (N x 6.25)	20		23.90±1.14^{cd}	24.95±0.15^{gh}	25.39±0.14^{hi}	23.21±0.38^{b}	22.12±0.42^{a}
	30	/	23.80±0.04^{cd}	25.55±0.14^{i}	25.51±0.10^{i}	23.16±0.05^{b}	23.06±0.87^{b}
	40		24.02±0.04^{cd}	23.73±0.43^{c}	24.49±0.49^{efg}	23.04±0.18^{b}	23.84±0.06^{cd}
	50	23.53±0.71^{bc}	24.03±0.18^{cde}	24.28±0.01^{def}	23.55±0.75^{bc}	23.80±0.16^{cd}	24.68±0.01^{fg}
Fat	20		5.77±0.09^{e}	6.42±0.07^{i}	6.16±0.30^{h}	6.18±0.11^{h}	5.93±0.03^{f}
	30	/	5.96±0.02^{fg}	5.97±0.00^{fg}	5.60±0.06^{cd}	6.04±0.11^{fg}	5.98±0.10^{fg}
	40		5.99±0.19^{fg}	5.92±0.00^{f}	5.46±0.02^{ab}	6.06±0.00^{gh}	5.63±0.04^{cd}
	50	5.69±0.01^{de}	5.55±0.01^{bc}	5.73±0.01^{de}	5.62±0.20^{cd}	5.38±0.16^{a}	5.67±0.02^{cde}
Ash	20		3.56±0.12^{defg}	3.46±0.07^{bcde}	3.55±0.20^{cdef}	3.47±0.11^{bcde}	3.71±0.26^{g}
	30	/	3.63±0.11^{fg}	3.31±0.01^{a}	3.47±0.09^{bcde}	3.57±0.05^{defg}	3.59±0.16^{efg}
	40		3.41±0.18^{abc}	3.51±0.15^{cdef}	3.34±0.10^{ab}	3.44±0.01^{abcd}	3.61±0.11^{efg}
	50	3.43±0.01^{abcd}	3.49±0.01^{bcdef}	3.47±0.17^{bdce}	3.60±0.19^{efg}	3.40±0.14^{abc}	3.52±0.08^{cdef}

Data represent averages of three independent trials± standard deviation.
[a-l] For the same parameter means within the same column and line inscribed with different superscript letters are significantly different ($p < 0.05$).

Table 2. Effect of starch types and starch incorporation level on physicochemical properties of cooked patties (%FM)

	Rates	$P_{Control}$	PSi	PT	PV	PQ	PS
Moisture	20		67.26±0.50^{hi}	67.15±0.21^{ghi}	66.43±0.30^{defgh}	67.56±0.21^{i}	66.01±1.82^{bcdef}
	30	/	66.83±0.16^{fghi}	66.86±0.60^{fghi}	66.42±0.26^{defgh}	66.48±0.41^{defgh}	65.97±0.67^{bcde}
	40		66.32±0.38^{cdef}	66.72±0.70^{efghi}	65.89±0.26^{abcde}	66.22±0.40^{bcdef}	65.79±0.61^{abcd}
	50	65.73±0.47^{abcd}	65.39±1.01^{ab}	65.84±0.25^{abcd}	65.65±0.36^{abcd}	65.53±0.45^{abc}	65.10±0.54^{a}
Proteins (N x 6.25)	20		24.16±0.90^{abc}	25.29±0.36^{def}	28.34±0.48^{g}	23.87±1.02^{ab}	25.05±0.43^{cdef}
	30	/	23.83±0.30^{ab}	27.74±0.71^{g}	25.57±0.44^{ef}	23.92±1.47^{ab}	27.32±2.33^{g}
	40		25.74±0.06^{f}	25.77±1.32^{f}	25.65±0.22^{ef}	23.14±0.10^{a}	23.97±1.37^{ab}
	50	23.80±0.16^{ab}	24.32±0.37^{bcd}	24.61±1.43^{bcde}	24.39±0.35^{bcd}	25.37±0.35^{def}	24.80±0.51^{bcdef}
Fat	20		6.42±0.91^{a}	6.15±0.68^{a}	6.41±0.38^{a}	6.36±0.43^{a}	6.05±0.54^{a}
	30	/	6.30±0.97^{a}	6.43±0.69^{a}	5.61±1.08^{a}	6.16±0.69^{a}	6.26±0.75^{a}
	40		6.44±0.70^{a}	5.94±0.59^{a}	6.62±0.60^{a}	5.86±0.94^{a}	6.18±0.90^{a}
	50	6.07±0.81^{a}	6.11±1.10^{a}	6.09±0.76^{a}	6.37±0.67^{a}	6.56±1.03^{a}	6.23±0.68^{a}
Ash	20		3.55±0.05^{bc}	3.51±0.15^{abc}	3.68±0.10^{c}	3.47±0.12^{abc}	3.54±0.38^{bc}
	30	/	3.54±0.07^{bc}	3.49±0.10^{abc}	3.50±0.23^{abc}	3.38±0.19^{ab}	3.54±0.26^{bc}
	40		3.43±0.05^{ab}	3.33±0.11^{ab}	3.47±0.20^{abc}	3.41±0.25^{ab}	3.42±0.17^{ab}
	50	3.42±0.06^{ab}	3.38±0.07^{ab}	3.31±0.16^{a}	3.47±0.20^{abc}	3.34±0.15^{ab}	3.41±0.13^{ab}

Data represent averages of three independent trials ± standard deviation.
[a-i] For the same parameter means within the same column and line inscribed with different superscript letters are significantly different ($p < 0.05$).

The moisture contents ranged between 65.54±0.61 and 67.88±1.22 % for raw patties and from 65.10±0.54 to 67.56±0.21 % for cooked ones. The results of variance analysis showed that moisture varied according to starch type and starch incorporation level used for both raw and cooked patties. This was expected and can be attributed to the differences in the physicochemical composition of the starches used and most especially to their moisture content.Water content of control ($P_{Control}$) raw patty was not significantly different (p>0.05) to those of the raw patties *Psi*, *PT* and *PV* at the same level of incorporation (50g/kg of batter), the same result was obtained in raw patties *PQ* and *PS* with only 30g of starch per kg of batter. After cooking the same trend was not observed. Moisture content of all the patties was not significantly different (p>0.05) from that of control and up till 20g/kg of batter, moistures content of *PSi*, *PT*, and PQ was significant (p<0.05) than that the control.Because of the moisture loss during cooking, water content of cooked patties was lower than that of their raw counter parts. For the same reason protein and fat percentage was higher in cooked patties than in raw ones. Results clearly showed that cooking increased the fat content on a percentage basis, in all formulations, these results are in good agreement with those obtained by Hoelscher *et al.* [26], Berry [27] and Troutt *et al.* [28]. Tornberg *et al.* [29] concluded that the dense meat protein matrix of low fat ground beef prevented fat migration. As for moisture content, proteins and fats content varied according to starch type and starch rate used for both raw and cooked patties.

Starch type and its rates of incorporation statistically influence (p<0.05) ash content of raw patties while after cooking, neither starch type nor it incorporation rate significantly influence ash content of patties. This observation is linked to low ash content of the starch used in this study (0,11±0,01 to 0,33±0,02%) [17] but also to the drainage of soluble minerals resulting from cooking losses and punching out with molds.

3.2. pH, Water Holding Capacity, Cooking Loss and TBA Index of Patties

pH values of cooked and uncooked patties were not significantly different (P>0.05) among treatments (Table 3).

Table 3. pH and Water Retention Capacity (WRC) of patties

	Rates	$P_{Control}$	PSi	PT	PV	PQ	PS
pH Raw	20		5.79±0.06^{a}	5.80±0.07^{a}	5.78±0.05^{a}	5.78±0.08^{a}	5.74±0.12^{a}
	30	/	5.79±0.10^{a}	5.80±0.07^{a}	5.81±0.08^{a}	5.76±0.12^{a}	5.79±0.10^{a}
	40		5.78±0.07^{a}	5.79±0.09^{a}	5.79±0.09^{a}	5.80±0.10^{a}	5.76±0.14^{a}
	50	5.72±0.09^{a}	5.80±0.08^{a}	5.76±0.12^{a}	5.74±0.15^{a}	5.79±0.08^{a}	5.77±0.08^{a}
pH Cooked	20		6.31±0.04^{a}	6.27±0.05^{a}	6.29±0.04^{a}	6.28±0.05^{a}	6.29±0.04^{a}
	30	/	6.30±0.05^{a}	6.30±0.05^{a}	6.29±0.04^{a}	6.29±0.04^{a}	6.31±0.04^{a}
	40		6.30±0.02^{a}	6.31±0.05^{a}	6.30±0.04^{a}	6.31±0.05^{a}	6.29±0.05^{a}
	50	6.29±0.06^{a}	6.28±0.06^{a}	6.27±0.03^{a}	6.31±0.04^{a}	6.30±0.04^{a}	6.28±0.04^{a}
WHC	20		77.72±0.38^{bcd}	76.47±0.98^{ab}	78.96±1.91^{cd}	77.90±0.60^{bcd}	78.95±0.09^{de}
	30	/	78.80±0.65^{de}	76.86±0.38^{bc}	77.93±0.90^{bcd}	79.59±1.86^{e}	79.05±1.91^{de}
	40		80.03±1.25^{ef}	77.04±0.76^{bc}	76.77±1.19^{bc}	78.90±0.90^{de}	76.98±1.88^{bc}
	50	76.78±1.95^{bc}	81.50±0.92^{f}	77.96±1.85^{cd}	75.20±0.58^{a}	78.11±1.91^{cd}	76.83±0.42^{bc}

Data represent averages of three independent repeats ± standard deviation.
$^{a-f}$ For the same parameter means within the same column and line effect with different superscript letters are significantly different (p < 0.05).

These results were similar to those obtained by Troutt *et al.* [28]. The pH values increased upon heating, similar results were observed on beef patties formulated with various animal fats and essential oils [30]. This increase of pH values could be related to the breaking of sulfur or imidazole linking of amino acids content in meat during cooking [31].

Starch rate significantly (P<0.05) affected the WHC of raw patties. The same trend was observed for some starch type at the same percentage of incorporation, this can be due the differences observed in functional properties of these starches [17] and their interaction with other constituent of the patties [32].

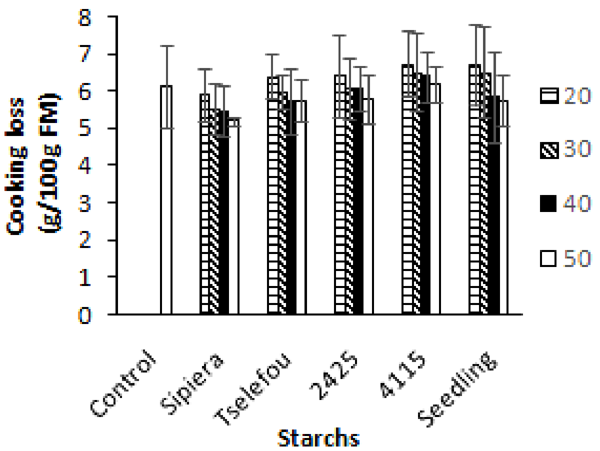

Figure 1. Influences of starch type and starch rate on Cooking loss of cooked patties

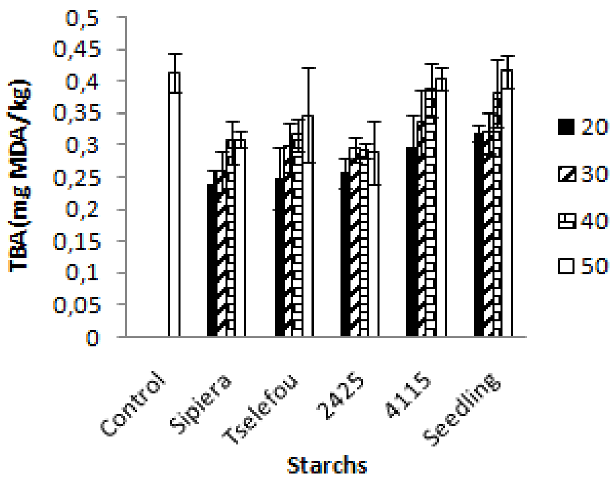

Figure 2. Influences of starch type and starch levels on Thiobartituric acid values of cooked patties

Cooking losses of patties (Figure 1) increased, but not significantly (P>0,05) with the percentage of starch incorporation. Cooking yield was improved (P<0.05) at the lowest starch incorporation (20%) irrespective of the starch type.

The results of the influence of starch type and incorporation rate on lipid oxidation of patties (Figure 2) are consistent with those of cooking losses Irrespective of the starch type the best yield is obtained with the lowest starch incorporation (20%), since TBA index increased (P<0,05) with starch incorporation except for starch *2425*. The Presence of minerals such as iron (pro-oxidant) in starch can explain the increase in lipids oxidation of patties [33].

3.3. Texture Attributes of Cooked Patties

Table 4 shows that the mean values for textural properties: hardness, cohesiveness, springiness and chewiness of patties were in the range 7.62±0.17 to 22.76±0.88 (N), 0.67±0.02 to 0.79±0.05, 0.57±0.00 to 0.97±0.02 (mm) and 3.43±0.26 to 16.68±0.16 (Nxmm), respectively. Starch incorporation rate increased (P<0.05) sample hardness and chewiness value. The increasing hardness might have been due to the reduction of moisture content of patties with increasing starch incorporation percentage (Table 1). These data were similar to the results of Ziegler *et al.* [34] who tested several types of dried and non dried sausages and reported that hardness decreased with moisture. Claus *et al.* [35] suggested that at higher water levels, the muscle proteins interact with the water rather than form cross-bridges that would increase hardness of beef/pork bologna. These results are also in good agreement with those reported by Carballo *et al.* [36] who indicated that the presence of starch had a significant increase in the hardness of bologna sausage. At the same percentage incorporation the starch types also influenced (p<0.05) hardness and chewiness. Cohesiveness and Springiness were significantly influenced (P<0.05) by starch type and the incorporated rate. For all texture attributes, values not significantly (P>0.05) different from control were obtained at some starch incorporation levels except for starch *2425* for Hardness, starches *Sipiera* and *Seedling* for Springiness and starches *Sipiera*, *Tselefou*, *2425* and *4115* for Chewiness. It is evident from the Principal components analysis of texture attributes of cooked patties (Figure 3) that the patty prepared with Seedling starch at incorporation rate of 40g/kg of ground meat (*PS40*) is the most similar to the control patty.

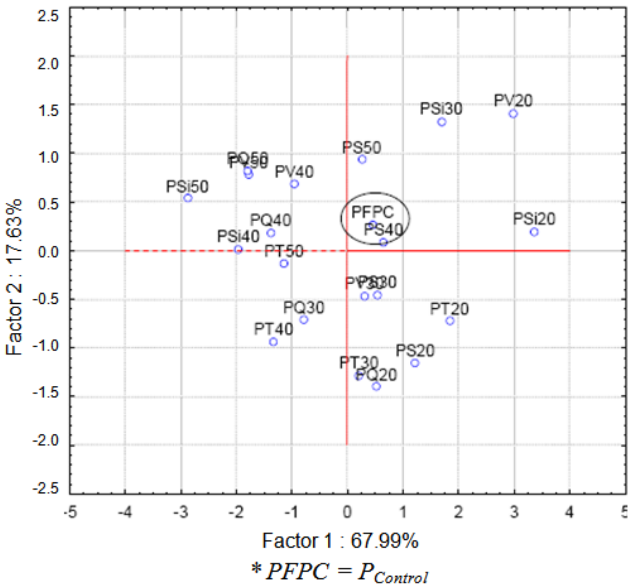

Figure 3. Principal components analysis of texture attributes of cooked patties

Table 4. Texture attributes of cooked patties

	Rates	$P_{Control}$	PSi	PT	PV	PQ	PS
Hardness (N)	20		7.62±0.17^{a}	9.89±0.25^{b}	11.92±0.20^{bcd}	10.94±0.02^{bc}	11.48±0.33^{bcd}
	30	/	14.90±0.06^{e}	11.30±0.40^{bc}	12.14±0.14^{cd}	15.78±0.51^{e}	13.62±0.74^{de}
	40		19.02±0.03^{fg}	15.44±0.79^{e}	19.19±1.12^{fg}	18.39±0.35^{f}	15.15±0.75^{e}
	50	15.54±0.88^{e}	22.76±0.88^{h}	18.19±0.11^{f}	21.45±0.16^{h}	20.71±0.39^{gh}	18.03±1.47^{f}
Cohesive-ness	20		0.69±0.04^{ab}	0.70±0.02^{abcd}	0.68±0.01^{a}	0.74±0.03^{cdefh}	0.67±0.02^{a}
	30	/	0.71±0.02^{abcde}	0.77±0.01^{fghi}	0.79±0.05^{i}	0.74±0.02^{cdefg}	0.72±0.01^{abcde}
	40		0.78±0.03^{hi}	0.78±0.00^{hi}	0.75±0.01^{a}	0.77±0.01^{ghi}	0.69±0.06^{ab}
	50	0.71±0.03^{abcde}	0.77±0.04^{fghi}	0.73±0.01^{bcdef}	0.75±0.02^{efgh}	0.78±0.01^{ghi}	0.70±0.03^{abc}
Springi-ness (mm)	20		0.65±0.00^{b}	0.84±0.02^{de}	0.57±0.00^{a}	0.94±0.00^{i}	0.97±0.02^{j}
	30	/	0.65±0.01^{b}	0.92±0.01^{h}	0.79±0.06^{c}	0.97±0.02^{j}	0.89±0.03^{g}
	40		0.92±0.00^{h}	0.97±0.00^{i}	0.84±0.01^{de}	0.88±0.01^{fg}	0.86±0.01^{ef}
	50	0.83±0.03^{d}	0.95±0.00^{ij}	0.96±0.00^{ij}	0.89±0.02^{g}	0.84±0.02^{d}	0.80±0.01^{c}
Chewi-ness (Nxmm)	20		3.43±0.26^{a}	5.84±0.43^{c}	4.68±0.66^{b}	7.67±0.34^{e}	7.49±0.13^{de}
	30	/	6.83±0.12^{d}	7.97±0.33^{e}	7.64±0.14^{e}	11.35±0.89^{h}	8.68±0.87^{f}
	40		13.72±0.66^{kl}	11.73±0.47^{hi}	12.05±0.99^{ij}	12.52±0.49^{j}	9.03±0.23^{f}
	50	9.18±0.57^{f}	16.68±0.16^{m}	12.68±0.17^{j}	14.23±0.85^{l}	13.55±0.48^{k}	10.10±1.10^{g}

Data represent averages of three independent repeats ± standard deviation.

$^{a-f}$ For the same parameter means within the same column and line effect with different superscript letters are significantly different (p < 0.05).

3.4. CIE Lab Color Attributes of Cooked Patties

Table 5 shows mean color attributes values of patties. Lower starch incorporation (2%) led to significantly higher lightness (L*) for patties formulated with potato starches (*PSi* and *PT*) while the contrary is observed for patties prepared with cassava starches (*PQ* and *PS*), except for *PV*, a patty formulated with cassava starch that was not significantly influenced by starch incorporation. These differences in lightness of the cooked patties are probably due to differences of the lightness of starch as observed by Mbougueng *et al.* [17] and their interaction with the constituents of patties. At the same incorporation level, starch type significantly (P<0,05) influenced lightness of patties.

Redness (a*) and yellowness (b*) values were between 11.14±0.08 and 13.81±0.78 and between 14.35±0.06 and 17.67±0.14 respectively. Meat redness was due to the concentration of myoglobin which contributes to the darker color. The redness of patties decreases (p<0,05) with an increase in the incorporation of potato starches, while a reverse trend is observed for patties formulated with cassava starches (*PV*, *PQ* and *PS*).In the first case, the difference in colour of the patties can be attributed to the dilution of meat myoglobin up to some extent to the colour of the starches. Yellowness values of beef patties were also significantly affected (*P*<0.05) by starch type and rate of incorporation.

Table 5. The CIE Lab color attributes of patties

	Rates	$P_{Control}$	PSi	PT	PV	PQ	PS
L*	20		$51.40±1.12^{ghi}$	$53.30±0.61^{j}$	$50.60±1.52^{defgh}$	$49.65±1.26^{bcd}$	$49.57±0.34^{bcd}$
	30	/	$49.60±1.53^{bcd}$	$51.13±0.60^{fghi}$	$50.05±1.79^{bcdef}$	$49.14±0.15^{abc}$	$51.75±0.39^{i}$
	40		$49.94±0.37^{bcde}$	$50.68±0.48^{defghi}$	$50.35±0.43^{defg}$	$50.21±0.47^{cdef}$	$51.65±0.69^{hi}$
	50	$50.17±0.45^{cdef}$	$48.23±0.39^{a}$	$48.99±0.25^{ab}$	$50.86±0.37^{efghi}$	$51.36±1.87^{ghi}$	$50.44±0.17^{defg}$
a*	20		$13.24±0.56^{ij}$	$13.01±0.92^{fghi}$	$12.01±0.96^{bcde}$	$11.64±0.13^{abc}$	$11.55±0.50^{abc}$
	30	/	$13.15±0.19^{hi}$	$12.10±0.60^{cde}$	$11.89±0.54^{bcde}$	$12.18±0.02^{cde}$	$12.46±0.62^{defg}$
	40		$12.36±0.27^{def}$	$12.07±0.59^{cde}$	$11.40±0.24^{ab}$	$12.16±0.13^{cde}$	$12.51±0.03^{efgh}$
	50	$13.81±0.78^{j}$	$11.82±0.14^{bcd}$	$12.00±0.59^{bcde}$	$11.14±0.08^{a}$	$12.45±0.06^{defg}$	$13.05±0.09^{ghi}$
b*	20		$15.23±0.84^{b}$	$16.56±0.86^{cde}$	$17.32±0.38^{fgh}$	$16.89±0.45^{def}$	$16.07±0.25^{c}$
	30	/	$15.45±0.48^{b}$	$16.99±0.50^{efg}$	$16.32±0.16^{c}$	$17.29±0.11^{fgh}$	$15.47±0.31^{b}$
	40		$16.28±0.56^{c}$	$17.49±0.02^{gh}$	$16.59±0.07^{cde}$	$16.86±0.66^{def}$	$14.54±0.18^{a}$
	50	$15.40±0.29^{b}$	$17.67±0.14^{h}$	$17.47±0.03^{gh}$	$16.46±0.01^{cd}$	$16.93±0.32^{def}$	$14.35±0.06^{a}$

Data represent averages of three independent repeats ± standard deviation.

$^{a-f}$ For the same parameter means within the same column and line effect with different superscript letters are significantly different (p < 0.05).

4. Conclusion

The results of variance analysis showed that moisture content varied according to starch type and starch incorporation level for both raw and cooked patties. Cooking yield was improved (P<0.05) by the lowest rate of starch incorporation (20%) irrespective of starch type. Thus, as far as texture attributes of cooked patties are concerned cassava starch (Seedling) can be successfully used to control binding properties of beef patties. Local starches appear to have potential as an extender in finely ground meat products.

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