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Effects of the added sugar on some physicomechanical and sensory properties of maize patties (*ike/klaklou)* rolled in-sticks-like of Benin

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Abstract

In Benin food, manufactured patties from Zea-Mays grains, peanuts, cassava, yams, were largely well prized. Scientific knowledge of production technique should be ensured for improving decoulant patties quality. Implicated changes, due to sugarcane inclusion to formulation of the seasoned maize dough fried into patties, were analyzed in this article. Confectioned six variant patties, corresponding respectively to 0% (control), 5%, 10%, 15%, 20% and 25% sugarcane (wt/wt.mix) incorporated percentages into maize dough formulation, were characterized, physically (residual moisture, bulk density, expansion ratio), mechanically (breaking strength) and sensory (color, taste, tasters personal feel).Obtained experimental results allow concluding that, added sugar ratio increase in patties formulation-confection provokes significant effects on patties physical and mechanical characteristics with growth levels respectively of: residual moisture 29-41%,apparent density 10.33-28%, volumetric expansion ratio 22.6-57.6% and breaking strength 25.7-78.5%. Patties' deeper color caramelizing and crustiness reduction have been also recorded. Nevertheless, results of the effected surveys, relative to taste/flavor and tasters' personal feel, clearly showed consumers' predilection towards sugar incorporated patties variants.

Keywords: Maize patties, bulk density, expansion ratio, breaking strength, crustiness.

Introduction

Among the grown plants in the world, maize (Zea Mays L.), also called Indian corn in Canada, is one of important cereals occupying nowadays most planted areas: more than 140million hectares[1,2]. World maize production was 839 million tons in 2013 against 860 Mt in 2011-2012, for a consumption of 866.7 Mt, making maize the world's most cultivated cereal with 41%, before the wheat 40%[3]. In Africa, maize is grown on almost the entire continent. It remains the most produced cereal: cultivated area of more than 25 million hectares and over 35 Mt/year. Maize production continues to progress slowly in Benin: 1,165 Mt in 2011-2012 and 1,174 Mt in 2012-2013 against 867 Mt in 2008-2009[4]. Maize dominant position is helped by its ability to adapt to agro-ecological conditions and strategic roles, both as cash corpses high consumption product in many countries[1,5-6]. Maize consumption varies greatly according to life standing levels: about 30 kg for each habitant yearly in the developed countries against 140 kg / habitant a year in the developing ones[7]. In the latters, particularly in Benin, in the last three decades, maize was essentially reserved for human food and animals feed. Among Benin food crops, maize undeniably offers the largest potential number of food transformations: over forty derivatives[7], including the rolled into sticks-like maize patties locally called "ike (in Yoruba)" or "klaklou (in Fon/Goun)" languages in Benin and surroundings[8-10]. Normally belonging to finger foods category, maize patties (ike/klaklou), like peanut patties, are highly prized by large segments of Benin populations[8-10]. However, most of the applied handicraft technologies in maize processing were drawn from local cultural heritage i.e. domestic methods transmitted and perpetuated through family education, gradually integrated and used on a larger scale in trading activities[11,12]. Scientific study on patties processing subject is very poor, seeing queasily inexistent. Local manufacture and marketing of maize patties constitutes a traditional daily carried out activity in many regions of Benin[9, 10,13], because maize patties are usually consumed at breakfast, afternoon snack, often even at all times of day. Sold at affordable prices, they are also very popular due to the displayed typical crunchiest noises under teeth: crustiness. Patties manufacturing process has been recognized not to be solely complex to apply, but remains very tedious[2,9,10,14]. Production transfer way, from traditional method to semi-industrial or industrial scales, is firmly connected to scientific and technological mastery of process. Otherwise, no quality improvement can be achieved for resultant maize patties.

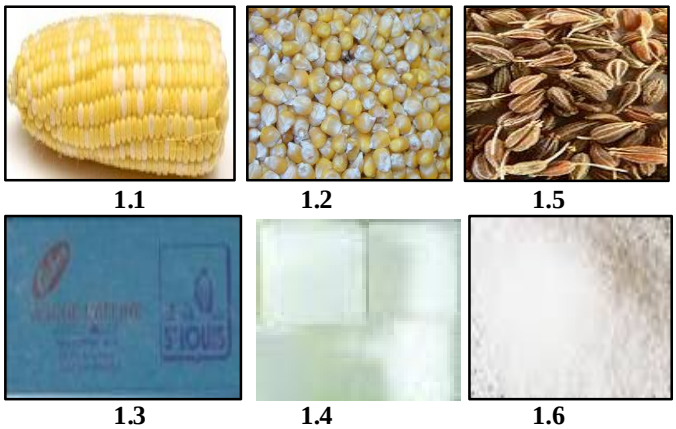
A better understanding of the patties manufacture's governing

physicochemical mechanisms shall constitute its mastery's guarantee. In course of actions, current article deals with effects study of the added sugar, to formulation of seasoned maize dough fried into sugary variant patties, on some targeted physical, mechanical and sensory characteristics of these products.

Materials and Methods

Study sites: Accomplishment of current described study takes place on the installed equipments belonging to three physical partners. First, is Mrs. Mary AZEDJO traditional production unit, at Midokpo quarter, in Godomey-Togoudo District where has been developed ability for mastery of the rolled-into-sticks patties manufacturing process. The used two other types of equipments are for patties characteristics determination and belong respectively to Laboratory of Applied Energetic and Mechanics (LEMA) and Laboratory of Research in Applied Biology (LARBA), both two from Polytechnic School of Abomey-Calavi (EPAC).

Involved Raw Materials in the Maize Patties Production: *Maize (Zea Mays L.): In view that actual investigation reaches consistent results with expected practices in patties field, the used maize seeds (Figure-1.1, 1.2) are those acquired from all coming variety bought at Dantokpa market (Cotonou, Benin)where patties producers are usually supplied. Physicochemical studies proved that West-African maize seeds were rich in carbohydrates, relatively poor in proteins and fats, primarily composed of starch (64.78% in dry basis), proteins (7-12%), fats (4-6%), sugars (1.0-3.0%), mineral substances (1.0-1.5%), fibers (2.0-2.5%), vitamins[6, 15].



1.1 **1.2** **1.5**

1.3 **1.4** **1.6**

Figure-1
Used raw materials: local maize (1.1) seeds (1.2); cane sugar (1.3) in cubes/lumps (1.4); culinary green anise (1.5); loose kitchen salt (1.6)

The most present vitamins in maize seeds were pro-vitamin A (in horny endosperm, especially of yellow maize), vitamin E (in germ) and most water-soluble vitamins, except vitamin B_{12}[16]. The maximum water content, for proper conservation of maize seeds, was evaluated to 13% [12,16]. In Benin, maize grains have and still been used as fine flours (ordinary dry, roasted, moist, fermented and dried awe, fermented dough less consistentogi), for finished products (cooked pasta of several types, fermented or unfermentedowooroka-lagba, amiwo, lio, akassa, ablô, gowé, come, akpan, mawè, ogi), as maize couscous (yèkè-yèkè), porridges (koko, aklui), donuts (avounmi, massa) and patties (ike/klèklè/klaklou) of various presentations of which the retained one in current study: sticks-alike shaped patties[4, 7].

*Green anise: Of scientific name *Pimpinell aanisum L.*, also called "Pimpinelleanise", green anise is an herb of Apiaceae (Umbelliferae) family, cultivated as condiment plant due to leaves and aromatic seeds utility (Figure-1.3). All plant parts are aromatic. Its seeds are used in pastries (gingerbread) and confectionery (sweets) and also added to many drugs to mask unpleasant tastes. Already used 4,000 years ago in Egypt, Greece and Roma[17], green anise fruit is agreenish-grayschizocarp, ovoid into two parts, flattened laterally, dimension of 3 to 5 mm-long, coarse hair sticky and clearly serrate.

*Kitchen salt: Used common kitchen salt (Figure-1.6) consists mainly of sodium chloride (NaCl), an indispensable substance to human body which remains unable to produce it by itself, similarly to vitamins[18]. Adult body contains between150 and 300g of salt and needs a daily intake of at least 3-5 g for losses compensation due to perspiration and excretions of bowel and urinary[19,20]. Salt is not a flavor enhancer but allows changing taste perception, generally making it more pleasant. It possesses dehydrating properties, plays several roles in fermentation, organoleptic quality, food conservation reducing water activity.

*White cane sugar: Coupled sometimes with salt for maize patties seasoning, St. Louis Brand white cane sugar (Figure-1.4) cut into cubes (Figure-1.5) and sold in commonly consumed 500 g cardboard has been chosen for this experimentations. It consists essentially of saccharose, by far, the most common produced carbohydrates by nature. Elaborated by photo synthesis, by a number of crops, commercialized sugar is industrially extracted from sugarcanes, beets, sweet maples sap, dates (date palm fruits), pineapples[21, 22].

*Water: The used water in reported research is from public network, provided by National Water distributor Society of Benin (SONEB). Water is known as an essential component, a key factor in formulation and rheological behavior of pastas[23]. These studied maize dough formulations cannot escape from such the noticeable water actions. Indeed, the author obtains that, adding water to pasta formula reduces its viscosity and elasticity (consistency) but increases its extensibility, fluidity and adhesion. Contrary, if the water proportion is too low, the dough becomes brittle and shows a marked crusting due to rapid dehydration on its surface, as it's shown by some recorded investigations results[24,25]. Depending on the physical state of the

starch granules after cooking, the finished products possess great else less ability of water-vapor absorption.

Maize Patties Manufacturing Procedure

Drawn lessons from preliminary works: Shaped into sticks-like maize patties are variously named, depending on ethnic groups forming Benin populations, "ike" in Yoruba, "klaklou" in Goun and "klèklè", "aklèklè" in Fon are examples' names. Produced maize patties (ike/klaklou) in Benin are not the same products as the known wide spread tortillas[26]. They are prepared from a pre-cooked salty porridge (added of sugar or not), consolidated by mixing with dry crude maize flour and then hot-oil fried according to indicated sequences of processing flowchart of Figure- 2. Except some isolated cases, most patties producers integrated a green anise to porridge as flavoring ingredient whose unique role was to impart its flavor for improving organoleptic quality. Quantitative measurements have been effected during preliminary investigations and field campaigns, especially during the devoted practicum to mastery of manufacturing process in Marie AZEDJO's patties production unit. These done works allowed us collecting data revealing that, for craft method of fabrication of maize patties (ike/klaklou), 1kg of maize flour required, 200g of sugar (20% wt/wt/mix), 18-19 g of kitchen salt (1.8-1.9%), 1.8-2.0 g of green anise (0.18-0.2%) and 3 L of potable water directly involved in confection process. Indeed, this water amount did not include committed part to clean various implied equipments and raw materials or connected usages. In finished product form, sticks shaped patties were relatively cylindrical, frustoconical ends, having lengths comprised between 17 and 20 cm. Their average diameters varied from 5.4 mm to 8.5 mm and sometimes up to 10 mm depending on their selling prices.

Manufacture of patties really started by the flour fractionation step where available maize flour quantity was divided into unequal two parts: three quarters (3/4) for dough formulation-preparation and the last quarter (1/4) for consolidation of the flavored and added sugar dough in petrifying–mixing step.

Patties Variants Formulation: For current characterization study, six (06) variants of maize patties "ike/klaklou" (MP) were confectioned consecutively to the carried out preliminary experiments with technological assistance of the patties producers in field. Table-1 summarized different percentages of the used raw materials in formulation-confection of the studied maize patties variants. They were respectively labeled as:1-pure maize flour made Maize Patties i.e. no kitchen salt (0%) and no sugar (0%) added variant (MPW00) taken as witness/blank; 2-confectioned maize patties variant using salt ratio of 1.8% without any added sugar (0%) labeled $MPSS_0$ and 3, 4, 5 and 6 manufactured four variants containing salt ratio of 1.8% with added sugar respectively at 10% ($MPSS_{10}$), 15% ($MPSS_{15}$), 20% ($MPSS_{20}$) and 25% ($MPSS_{25}$), percentages expressed in sugar-weight to mix-weight (wt/wt.mix) according to detailed composition in Table-1.

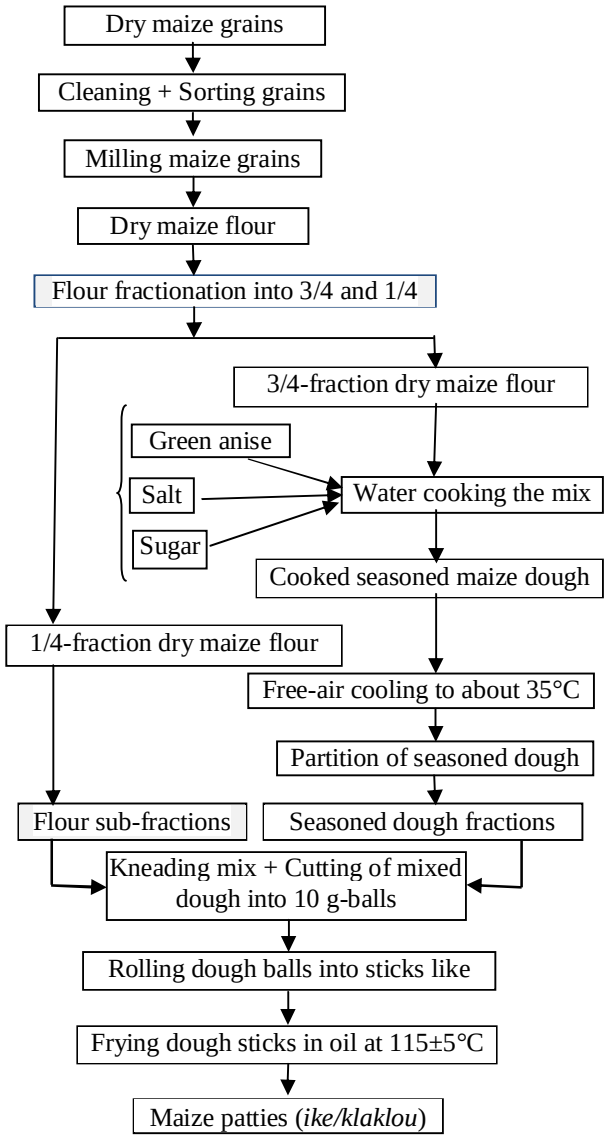


Figure-2
Maize processing flowchart into so-called maize patties (ike/klaklou) in Benin

Seasoned Dough's Confection: Seasoned dough's manufacture consists on operations' steps resulting in obtention of the cooked and sweet-flavored dough using the first 3/4-fractionmaize flour. For cause, considering 1 kg maize flour, seasoned dough formulation–cooking is carried out on 3/4-fraction: 750 g. Procedural executions can be summarized in followed six (6) operative steps:

1-dilute, approximately 500 g of first maize flour fraction in 3 L of water in properly washed cooking pot by adding about 2 g (exactly 1.8 g) of green anise dry seeds;

2-heat obtained suspension to boiling, by continuously stirring it with the aid of a wooden pallet, in order to homogenize the mix and avoid formation of taken-in-masses giving lumps;

3-add about 18.5 g of kitchen salt by continuing to pallet homogenize the mix and let it boil for about 15 min;
4-add 200 g of white cane sugar (corresponding to 20% mix total mass), constantly continuing to homogenize the mix and let it boil. In these conditions, substantially starch gelatinization occurs which is characterized by sticky appearance and boiling dough swelling;
5-add remain 250 g first maize flour fraction, whilst continuing to strongly mixing it until a firmed, sweetened and anise flavored maize dough be reached;
6-let the obtained dough bake about 5 min, after what, remove cooking pot from the fire and pour this sweetened and flavored maize dough in a breadth bowl and finally let it cool at ambient conditions.

Dough Partition, Mix-Kneading, Balls Cutting and Shaping into Sticks-like: Previous cooled dough, resulting from first fraction 750 g maize flour, is manually (or with a knife) divided in 4 or 5 averagely equal parts. Each dough part, supplemented of a portion of the remaining crude second flour fraction (250g, also divided in 4 or 5 portions), is then mixed-kneaded. Decoulant homogeneous mix (Figure- 3.1) is afterward cut into small balls of about 10g and modeled/rolled into sticks-like (Figure- 3.2). Such adopted procedure for dough partition in 4 or 5 is supported by the fact that, manual mixing-kneading of incorporated crude dry flour into cooked maize dough is very wearisome, due to the added sugar content which makes the seasoned dough much more elastic-plastic. So, if the entire quantity of cooked dough was once kneaded and leaved to rest a long time, intending for being cut into compulsory small balls, a novel kneading step should be unavoidable. Whereas, any resumption of kneading-mixing action became much more difficult when performed manually on a large dough mass than on successive small portions.

Fry-Cooking the Sticks-like Shaped Dough-Balls: During the 10 g dough-balls cutting and modeling into sticks-like, devoted oil to fry-cooking them is poured in roaster-pan, set on the fire and raised to 115±5 °C. At this temperature, initially red palm-oil becomes hot bleached (other selected edible vegetable oil may be used). It no longer crackles, thus stays quiet, as containing no more moisture. Therefore, the rolled into sticks-like crude seasoned maize dough (Figure- 3.2) are meticulously hot-oil immersed, for about 10 min frying. This staying time has been adopted following the collected data from preliminary carried out works during dedicated practical training for better mastery of manufacturing process. At mid-term (5 min), partially fried and cooked dough sticks are revolved using a perforated metal ladle. After second half staying-time of 5 min, fried-cooked patties are then oil removed and deposited in a combined sieving-vessel carrier for squeezing. In latter step, excess oil on patties walls is recovered. In patties hot-oil removal step, a relative sudden cooling indubitably occurs due to temperature difference, between hot-oil at 115±5°C and surrounding cold air at 39±1°C. Once free-air cooled, patties are then conditioned in packaging or plastic bags and accumulated either, in storage basket (production for sale), or in confectioned aluminum-foil satchels for further tests in above cited two laboratories.

In Figure-3 is disclosed an over view for selected four variants from the confectioned maize patties according to the detailed composition of seasoned dough's formulation in Table-1.

Materials for Patties Characterization: Laboratory equipments used in maize patties characterization are composed of:
*a digital laboratory Mettler EHW-ED Brand, displaying measurements range up to 3,000 g (0.1 g precision), for weighing different taken quantities of flour, sugar, salt, green anise, as required by each patties variant formulation and mass monitoring, for water content assessment and taken various masses of cut samples from the rolled-in-sticks, as well, for crude seasoned dough, as for fried-cooked patties;

Table-1
Dough formulation for the studied six (6) variants of Maize Patties (MP)

Maize Patties Variant		Dough components percents in mix (wt/wt.mix)			
Number	**Designation**	**Salt (%)**	**Green Anise (%)**	**Sugar (%)**	**Maize Flour (%)**
1	MPW00	0	0.18	0	99.82
2	$MPSS_0$	1.8	0.18	0	98.02
3	$MPSS_{10}$	1.8	0.18	10	88.02
4	$MPSS_{15}$	1.8	0.18	15	83.02
5	$MPSS_{20}$	1.8	0.18	20	78.02
6	$MPSS_{25}$	1.8	0.18	25	73.02
MPSS: Maize Patties made of Salt (S-%) and Sugar (S-%); W: Witness (no salt, no sugar)					

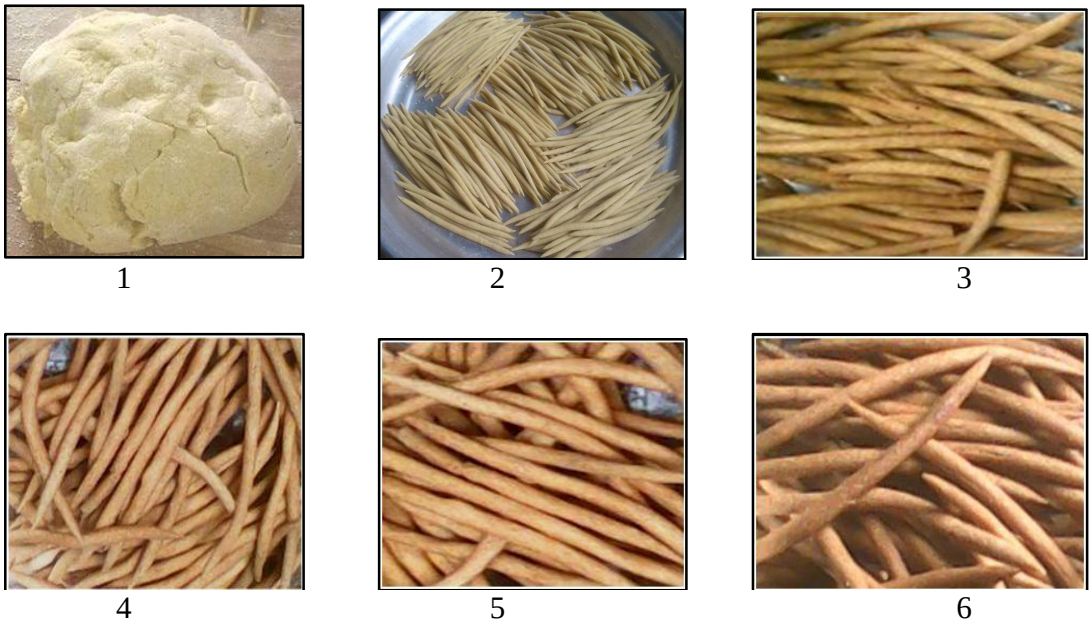


Figure-3
3.1. Kneaded dough mix; 3.2. Cut balls rolled into sticks; 3.3. Four of studied six variants maize patties: $MPSS_0$, $MPSS_{15}$, $MPSS_{20}$, $MPSS_{25}$

4.1 4.2

Figures-4: 4.1
Memmert D06060 L 400 Oven-Dryer set up to 105°C showing patties samples in gravimetric testing;
4.2-Lloyd Texture Analyzer with sample 3 in breaking strength test

* a ventilated hot-air oven-dryer, MEMMERT type D06060 Model 400 and temperature range from 30 to 225 °C, fitted with an air damper adjustment system of 0-6 (Figure- 4.1), for drying the shredded patties variants, for gravimetric determination of water content and the samples conditioning that precedes mechanical testing realization;
* a Texture Analyzer (Figure-4.2), available from Lloyd Instruments (division of AMETEK Company, electronic instruments and electromechanical devices manufacturer since 1930) and designed for testing physical integrity and mechanical properties of any food product, in particular in range from 0 to 1000 N.

For all the performed texture tests in radial compression on manufactured maize patties, Texture Analyzer machine was equipped with a Warner Bratzler probe and calibrated for displaying constant speed of 200 mm/min, in range forces from 4 to 150 N, to effect an elongation of 65cmat a the hole angle of 60°.

Apart from the formerly mentioned FACOM caliper, other used small tools are composed of various accessories, such as graduated plastic ruler (0-30cm) for pre-sizing patties samples to avoid losses by breaking, metal saw blades for cylindrical patties samples cutting, aluminum foil about 0.02 mm thick for packaging and marking patties samples during storage, adhesive tape and marker-pens for marking and identification of variants grouping samples.

The used equipments for manufacture of the studied six (06) patties variants (ike/klaklou), were, in fact, artisanally realized. They consist of: kitchen utensils (aluminum pots, wooden pallet, ladles, spoons, graduated flasks and beakers), coal, wood and matches to make fire, work table (for dough balls cutting and shaping or rolling into sticks like), trays and bowls for transport and handling, a combined sieve-bowl that allows maintaining the cooked patties for a relatively short stay-time (about 3 min), once out of hot-oil. It's indispensable for excess oil removal from patties walls. At this same time, cooling of fried patties takes place before wrapping and storage conservation.

Patties Trimming and Sampling for Various Analyses: Trimming is the set operative steps consisting to spot, in each of produced patties variant, those relatively denticalin diameter, to proceed to elimination of visually distorted ones, then cut each of them to assess twelve (12) cylindrical samples of equal30 mm-height (a selected sample length for all accomplished tests). This tiresome operation's cycle is therefore six (06) times repeated in current work, on each confectioned patties variant, at about 7-days intervals.

Maize Patties Evaluated Physical Characteristics

Residual Water Content: Residual water content of patties sample is evaluated according to procedure of AFNOR NF-90.93 standards. Three taken samples, each of about 10g crushed patties variant, using RETCH mill type, are collected in convenient small cups of known empty-masses (M_v). Entire cup-containing ground patties of mass (M_1) is then brought into MEMMER hot-air oven-dryer (Figure- 4.1) and dried at 103±2 °C for, at least, 8 hours during which, mass of samples is taken at one hour intervals. Drying is stopped when sample mass constancy reached, giving product dried mass (M_2), the constancy marked by three consecutive weighings. During these tests, coming out of oven-dryer and before each weighing, filled cup-samples are 10 min cooled in Nalgene ISO-9001 desiccator. Then, the sample's water content (W) is finally calculated applying the usual formula expressed in dry basis percent (db) as:

$$W = 100 \cdot (M_1 - M_2)/(M_2 - M_v) \qquad (\%) \qquad (1)$$

Bulk Density Estimation: The bulk density (ρ_A) of cylindrical shaped patty sample is evaluated as ratio of taken sample mass (M) on the open-air using laboratory Mettler to corresponding apparent volume (V_A), according to the known usual relationship:

$$\rho_A = M / V_A \qquad (2)$$

For accessing to the apparent volume (V_A), we've first measured dimensions of cut patties' sticks cylindrical samples using 150±0.01 mm digital caliper Facom brand, namely:

*samples length, seeing height (H): samples height (H) has been maintained constant and equal to30 mm for all of the realized tests in current investigation;

*patties apparent diameter(D_A): considered value for D_A was arithmetic average of three measured diameters (D_1,D_2, D_3) where D_1 was taken at 5 mm first end of sample, D_2 at sample middle (=15 mm), D_3 at 5mm of second end of 30 mm-height cut sample (=25 mm):

$$D_A = (D_1 + D_2 + D_3)/3 \qquad (3)$$

*sample apparent volume (V_A): Itis calculated by the aid of cylinder classical formula:

$$V_A = (\pi \cdot H \cdot D_A^2)/4 \qquad (4)$$

The value of patties sample bulk density (ρ_A, g/cm^3) is then assessed using equation (2).

Volume Expansion Ratio Evaluation: In adopted procedure, actual apparent diameter (D_{A0}) and height (H_0) of 30 mm cut sample of cylindrical like shaped stick seasoned doug hare measured prior to frying, giving sample's initial apparent volume (V_0). It's followed volume expansion ratio (ε_v in %) calculated by dividing100-times volume difference (V_0-V_A) by initial volume (V_0) according to formula:

$$\varepsilon_V = 100 \cdot (V_0 - V_A)/V_0 \qquad (\%) \qquad (5)$$

Where in (V_A) is apparent volume of 30 mm-height cut fresh sample of rolled seasoned and sugary maize doug hand (V_0) apparent volume of corresponding fried patty.

It should be stressed delicacy to observe in sizes (D, H) measurement son dough sticks samples using caliper, knowing that fresh rolled into stick maize dough remains relatively soft enough and therefore easily deformable, without required cautions.

From the six (06) formulated variants maize patties, cut samples into 30 mm-height x (actual diameter) are brought to dry into ventilated hot-air oven-dryer, set at 45 °C for 24 h. This applied pre-drying aims to place all studied variants of maize patties in identical homogenization conditions of temperature and humidity. So that, the latters do not constitute measurement's influencing factors for the applied mechanical tests, relating to material structure [25]. Once leaving oven-dryer, patties samples are packaged in aluminum-foil satchel, labeled and inserted into plastic bags, to avoid further humidification. Mechanical tests, in radial compression (patties diameter sense) are performed for breaking effort evaluation using Texture Analyzer Lloyd Instruments (Figure-4.2). Indeed, for objective and accurate measurement of food product hardness, texturometer /

penetrometer had been used simulating the chewing action of human mouth[27,28]. However, all sensorial parameters of food cannot be detected by means of texture analyzer device. Developed mechanical penetrometry method allows accessing to the called "crustiness effort" (E_C), an objective measure characterizing felt ease (convenience) by consumers who breaks (fractures) under teeth, extruded products cell-walls structure[28, 29]. The crustiness effort (E_c) was then objectively estimated according to formula:

$$E_C = F_{GM} / N_0 . \quad (6)$$

An extruded product is undeniably even more crusty, it presents, during crushing penetration, a high fractures number (N_0),corresponding to peaks intensity number above taken threshold set equal to 0.1N during solicitation time, under alow overall average force (F_{GM}). This is equal to integral of area (I_F) under force - time curve divided by solicitation time (t). Pursuing this author's results, we can consider that maize patty, similar to extruded product in that it undergoes expansion in frying, is especially more crusty, at constant fractures number N_0, that the applied crustiness effort E_C is low. Indeed, calibration of modern texture analyzer allows fitting penetration height and probe speed, maintaining so constant duration for all the tested food samples. Therefore, breaking force F_B (=F_{GM}) may well be rendered proportional to searched crustiness effort (E_C) near constant N_0 and E_C and express as following:

$$E_C = F_B / N_0 \Leftrightarrow F_B = N_0 \cdot E_C . \quad (7)$$

Targeted Sensory Characteristics Evaluation: Sensory analysis is based on three metrological levels: perception, identification and discernment. The taken three (03) sensory parameters into account in this patties characterization were: color intensity, crustiness (related to both the breaking force and chews number) and taster personal appreciation. Rating tests were exclusively focused on products to measure magnitude of differences between patties variants and rank them in ascending or descending intensity order of each selected parameter. Hedonic tests were designed to measure degree of appreciation of a product. Measure of sensation intensity was rendered coherent using special scales, little objective, since according to researchers, sensation varied from one person to another[30-33].A well-trained panel was normally required for sensory evaluation[34].

Particularity of performed sensorial tests, in current work, resides in the fact that, chosen tasters panel is not only, composed of untrained students (representative an important fringe of patties' usual consumers in Benin), but also and primarily that constitution of submitted products to taste was disclosed only at test ending.

Patties Visual Color Analysis: Color is one of first notable aspects for a finished product. It's often related to thermo-chemical, biochemical and microbiological phenomena that occur on and/or within food product during processing. Aware of these difficulties, dedicated patties to color testing, although from six (06) variants dough formulations (Table-1), were marks-identified, grouped and fried in same oil, at same temperature and staying time.

To evaluate patties color intensity, a categorization sheet-paper was designed to be fulfilled by respondents using a scale grading from 1 to 5 corresponding to following five (05) predetermined answers: 1 = Ordinary known color, 2 = Passably caramelized color, 3 = Fairly caramelized color, 4 = Well caramelized color, 5 = Highly caramelized color. Surveyed students number was limited to forty (40) to account for reserved patties amount specifically for finished products' color study.

Patties Crustiness Analysis: Crustiness is result of a complex set of elements. Crustiness or rather perception of crusty occurs when such food is broken by teeth which grind it by chewing. This sensory test is performed to try or not to validate mechanical measurements results in radial compression of the six (06) variants studied patties. Experience running consists, for surveyed tasters, to classify patties variants by checking their respective crustiness and attributing notation to be chosen between 1 and 5 of established gradual categorization scale and marked on handed score sheet paper. Each marked point has following signification: 1≡Mediocre crusty variant, 2≡Passable crusty variant patties, 3≡Fairly good crusty variant patties, 4≡Good crusty variant patties, 5≡Very Good crusty variant patties. Requested tasters number was forty (40), accounting for the limited patties amount for accomplishment of crustiness test.

Patties Taster's Personal Feel: Personal feel test is designed to assess satisfaction level of patties' consumers. Selected tasters number is forty (40), known limited amount of patties prepared for purpose. Each taster is called to assess each referred variant patties to him by marking the chosen note box matching its personal appreciation. For purpose, an established semantic scale rating (**1** to **5**) taste sheet-paper was delivered to each taster to be filled. Included instructions consisted on five (05) notations: 1≡Bad quality patties; **2**≡Passably beloved patties; **3**≡Fairlybeloved patties; **4**≡Good Beloved patties and **5**≡VeryGood Beloved patties.

Analysis and presentation of the collected experimental data were using the Microsoft Excel Office 2007software.

Results and Discussion

All displayed characteristic results, for the studied six (06)variants maize patties, are mean-values (M), followed by calculated standard deviation (σ) according to formula:

$$\sigma = (1/N) \cdot \sqrt{\sum_i X_i^2 - M^2} \quad (8)$$

The latter is known as dispersion indicator allowing to learn about how recorded (i=1 to N) values for each studied characteristic (X_i), are distributed around their mean-value (M).

Patties residual water content: Obtained results from residual water content evaluation for the studied six (06) maize patties variants were deployed in dry matter basis on Figure 5.One can clearly observe that, maize patties variant no added sugar (0%), but salted at 0.18% ($MPSS_0$), shows average water content value of 5.64±1.28% (db) lower to those fall other five studied variants: from $MPSS_{10}$ with 6.03±1.12% to MPW00 with 7.99±1.53%. The largest value of residual water content was registered for no salt (0%) and sugar (0%) incorporated control patties variant (MPW00) with 7.99±1.53% (db) ≈8%. Latter patties variant contained average water content almost equal to allowed high thresh old by Codex Aliment arius, a considered value as appropriate for efficient food packaging: 8% (db).

Moreover, this noticed difference behavior for water residual content between variant maize patties MPW00 (no salt, no sugar addition) and variant patties $MPSS_0$ (1.8% salt; 0% added sugar) was attributable to the provoked effects by added salt into seasoned dough substances structure. An attempt was made to explain such noticed results. We thought that, due to salt dehydrating chemical properties, including that of release, added sodium chloride prevented retention of water molecules by oil ones, favoring by this way their separation, as previously suggested by some authors[35]. Indeed, the added salt to formulation of this patties variant had contributed to some extent to weakening of H_2O-solid matter links, helping subsequently to release more water molecules from the solid structure. So, greater water vaporization occurred in frying step for $MPSS_0$ variant patties (letting low residual water content: 5.64±1.28%) compared to those for confectioned variant patties without any added salt MPW00 of 7.99 ± 1.53% (db). Confectioned variants maize patties using respective sugar ratios of 10% ($MPSS_{10}$), 15% ($MPSS_{15}$), 20% ($MPSS_{20}$) and 25% ($MPSS_{25}$) showed increasing behavior for residual water content mean-values versus sugar inclusion percentages (Figure-5). Connecting to no added sugar variant maize patties (MPW00), recorded increase ratios were of 6.91% for $MPSS_{10}$ to 41.13% for $MPSS_{25}$. An attempted explanation for this studied variable behavior was that, incorporated sugar to these baked patties formulation, generated recovery of some initially lost H_2O-solid substances links due to salt weakening actions added alone: carbohydrates were particularly targeted. Then, incorporated sugar exhibited, among other probable effects, the one giving novel initiation for retention of additional residual water amount in the structure of resultant patties variants in comparison with no added sugar ones. Statistical exploration was made for developed evolution by the collected data from the four (04) salty and sugary maize patties variants. It allowed assessing to function that adequately fitted data from residual water content (Wr, %) versus added sugar ratio (S_a, %) expressed as following:

$$W_r = 4.945 \cdot \mathrm{Exp}\left(1.95 \cdot S_a\right) \qquad (9)$$

An exponential law form, with a regression coefficient value of $R^2 \approx 0.99$.

Patties Evaluated Bulk Density: These recorded experimental data on apparent densities of studied six (06) variants maize patties are disclosed on Figure-6. These results let know that, average densities of all the manufactured six (6) variants maize patties were lower than pure water one (1g/cm^3). Density of salted (normal salt ratio 0.18%) not sugared patties ($MPSS_0$) variant (0.658±0.072 g/cm^3) handed the lowest value compared to five (5) others, including taken as witness MPW00 (0.684±0.06 g/cm^3) one.

A simple informal verification test has consisted of immersing in laboratory, different maize patties30 mm-height cut samples in distilled or drinking water (from public network), in 1L capacity glass beakers. Results of immersion tests showed that patties cut samples remained long-time floats on water surface, the required time for patties samples to become waterlogged: often more thanthirty30 minutes, before finally submerge.

These collected values for density (ρ_A) of cut patties samples in tested dimensions (height H=30 mm; apparent diameter D_A≅8.5-10 mm), have then proved that, studied patties became solid products of fairly porous structure at operating conditions and less dense than water ($\rho_A < \rho_{water}$) at fabrication ending.

Considering sugar added variants $MPSS_{10}$, $MPSS_{15}$, $MPSS_{20}$ and $MPSS_{25}$, recorded bulk density average values, ranging from 0.726±0.063 g/cm^3 for $MPSS_{10}$ to 0.842±0.082g/cm^3 for $MPSS_{25}$, displayed increase ratios of 10.33 to 27.96% relating to normally salted but no added sugar patties variant. These obtained experimental results allowed concluding to maize patties apparent density increase with regards to added sugar ratio's augmentation.

Statistical exploration was then effected for developed behavior by the studied four salted and sugared variants maize patties. Results showed that the polynomial function which adequately fitted the data from evolution of bulk density (ρ_A, g/cm^3) versus the added sugar ratio (S_a,%), may be expressed by the tendency equation expressed as:

$$\rho_A = 94.66 \cdot S_a^3 - 53.8 \cdot S_a^2 + 10.37 \cdot S_a + 0.132 \quad R^2 \approx 1 \qquad (10)$$

Evaluated Volume Expansion Ratio: Recorded data for volume expansion ratio study are deployed in Figure-7. We can observe that witness patties variant made of no salt, no additional sugar (MPW00), developed very low volume expansion ratio (0.89±0.52%): less than 1%. Even though very feeble, this mean-value proved existence of a slight increase of fried maize patties final volume. At the same time, variant patties, no sugar and normal salt added rate of 1.8% ($MPSS_0$) had deployed an average value of volume expansion rate of 0.34±0.29%, so far lower compared to that of taken variant as witness (MPW00). Such shown tendency to reduction or can collation of volume expansion ratio was attributed to these previously noticed weakening actions of added salt to formulation of the baked variant patties.

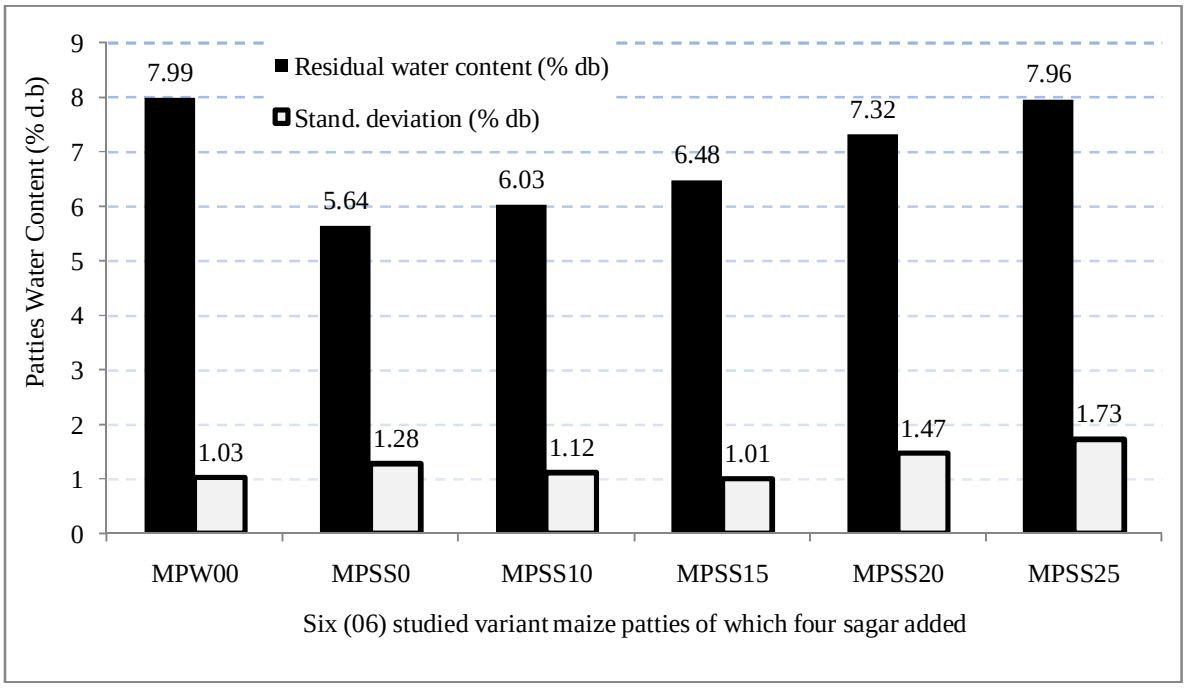


Figure-5
Average water contents (% db) of the studied six (6) variants maize patties

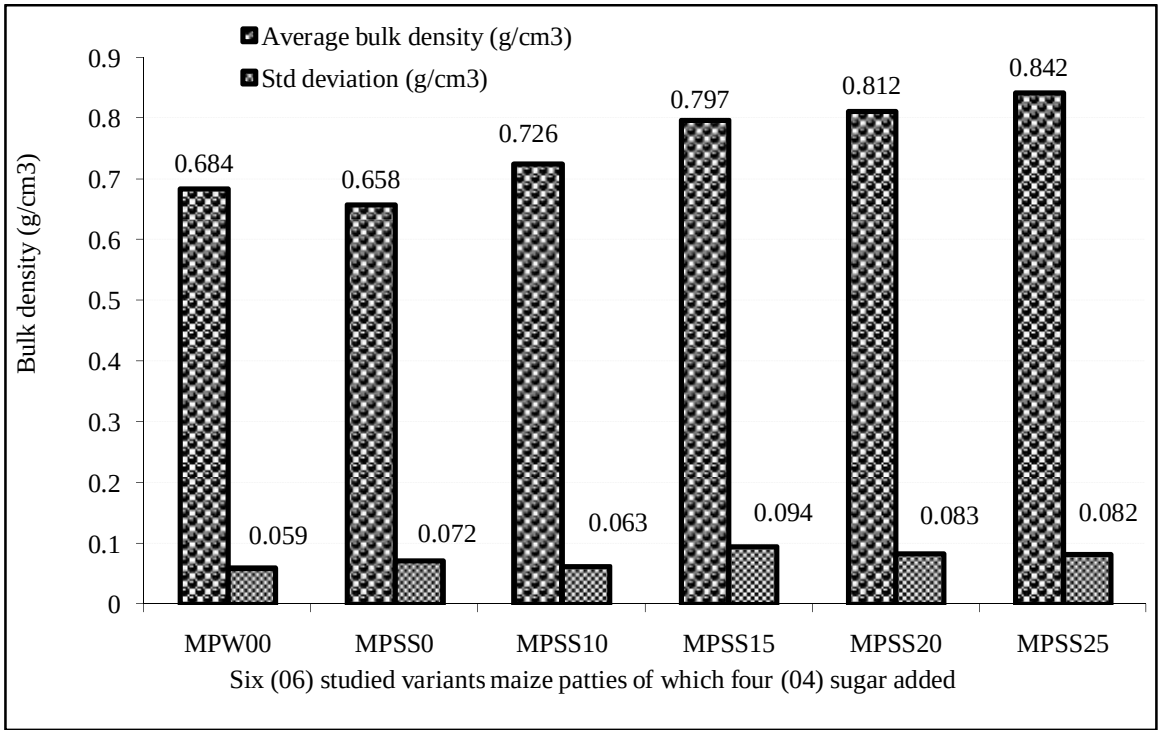


Figure-6
Bulk density's behavior of the studied six (6) variants maize patties

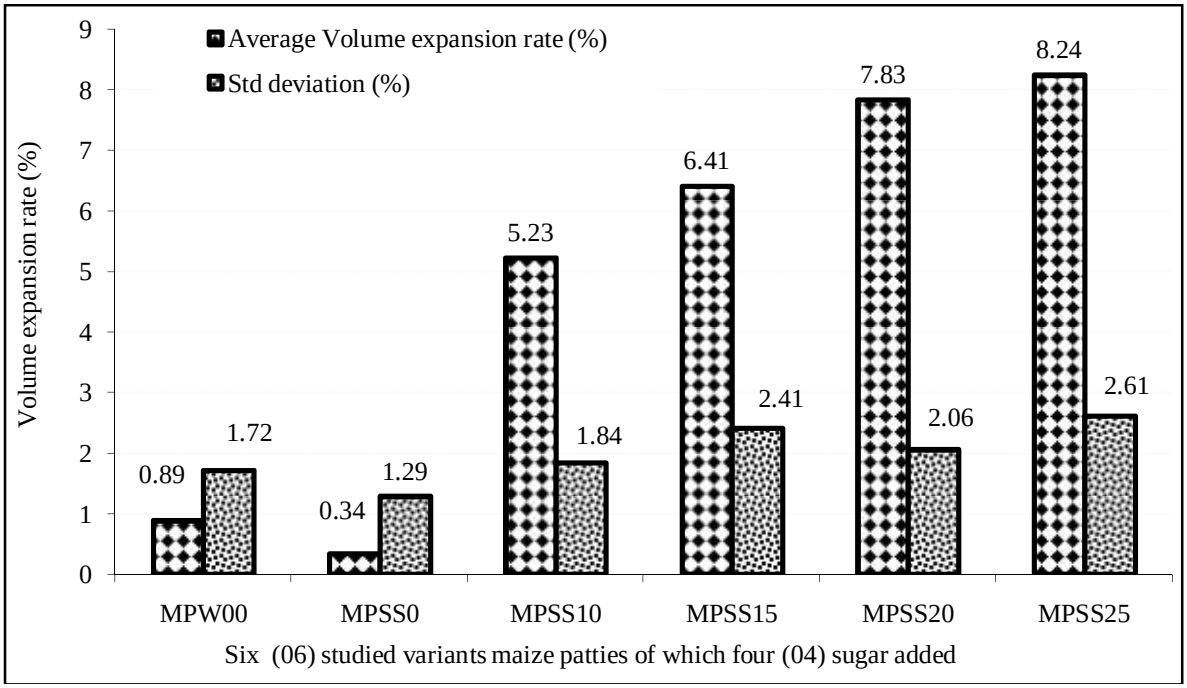


Figure-7
Volume expansion ratio ε_v (%) of the studied six (6) variants maize patties

Salt addition to dough formulation resulted then in patties stick's volume decrease and, consequently, that for volume expansion ratio, compared to those obtained from witness/control patties variant made of seasoned dough without any salt inclusion (MPW00). As opposed to this normally salted patties ($MPSS_0$), the recorded data relating to on salted and sugared patties variants, at respective percentages of 10% ($MPSS_{10}$), 15% ($MPSS_{15}$), 20% ($MPSS_{20}$) and 25% ($MPSS_{25}$), from 5.23±1.84% to 8.24±2.61%, corresponding to22.56 to 57.55% increase ratio, has allowed concluding to an augmentation behavior for volume expansion ratio with increase of the added sugar percentage.

Statistical exploration was here also done for developed behavior by the recorded data for these four (04) salted and sugared variants maize patties. Obtained results let us know that, mathematical function which adequately fitted the experimental data from volume expansion ratio (ε_V, %) versus the added sugar ratio (S_a, %) to formulation of such patties variants, may be represented by an exponential trend equation expressed as following:

$$\varepsilon_v = 3.447 \cdot \mathrm{Ln}(S_a) + 13.12 \qquad (11)$$

with a regression coefficient value of R^2=0.981.

Recorded Patties Breaking Strength: Collected data, from evaluation of the required force to fracture/break the studied variants maize patties in radial compression, were graphically displayed in Figure-8. They clearly showed that breaking strengths (B_S), for respectively no salt no sugar added patties variant (MPW00) and normally salt incorporated without sugar inclusion one ($MPSS_0$), were relatively low (from 43.72±4.93 N to 45.05±3.57N) contrary to the recorded strength values for the four (04) normally salted and sugared variants at ratio range of 10 to 25% (wt/wt.mix). The latters developed relatively higher breaking strengths, ranging from 56.62±3.64 N to 80.39±6.96 N matching fracture strengths ratio increase from 25.7% to 78.5%. Moreover, these experimental results also clearly showed that the studied maize patties variants breaking strength, in radial compression, developed increase trend versus added sugar percentages. Both identified noticeable differences were connected to exerted solidifying and hardening actions of added sugar to the formulation of such variants maize patties.

The polynomial function that adequately fitted obtained data on breaking strength (B_S, N) from analyzed four (04) salt and sugar in corporate variants maize patties, versus added sugar ratio (S_a,%), may be represented by drawn expression from the developed trend equation:

$$B_S = 558 \cdot S_a^{\,2} - 36.82 \cdot S_a + 54.62 \qquad R^2 \approx 1 \qquad (12)$$

The noticed relative increase for breaking strength behavior of sugar added maize patties variants seemed, a priori, in opposition with recorded tendency on volume expansion ratio. It was expected in fact, that higher expansion be accompanied by patties structure easier fracture. We've rather observed results proving that maize patties structure became denser, since their density, relating to no added sugar one (witness), also displayed increase ratios of 10.33 to 28%, depending on added sugar content.

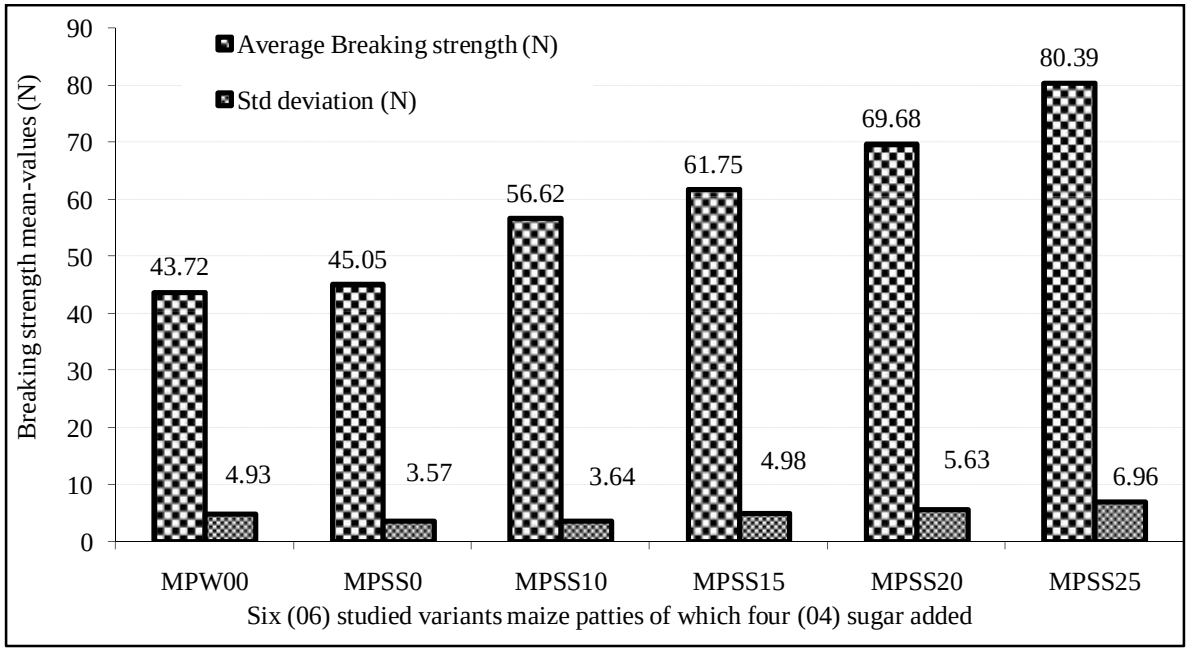


Figure-8
Breaking strength values from the studied six (06) variants maize patties

One could remark practical similarity between latter values and in corporated sugar contents of10 to 25%. At the same time, volume expansion ratio increase for sugar added patties, connecting to sugar-free variant one (0.34±0.29%), was exorbitant: over 1400- 2300%, whilst, based on sugary variants only, it still rose from 22.6 to 57.6%. It could be remarked that, breaking strength ratio augmentation of 25 to 78.5% corresponded to double to triple times the recorded ranging values for density. It was the proof of conferred consolidation by incorporated sugar to maize patties structure that became harder and more difficult to break.

Consequently, it did not promote sought good crustiness for sugared patties variants. We believed that this result might explain the fact that, in addition to its sweetening power, added sugar contributed not only, to aroma and texture formation through its binder qualities, to coloring and patties conservation, but also above all, possessed a plastic function as revealed by some results of carried out works on wheat[36,37]. One of fundamental properties of sucrose/saccharose was its high solubility in water due to molecular structure that promoted formation of hydrogen bonds. The water molecules were indispensable for solubilization of ingredients, proteins and carbohydrates hydration, gluten network development in dough. By water presence in excess, during formulation of these as on ed dough, giving maize patties, water affected nature of interactions between various components of formula and contributed to dry matter structuring prior to being discharged in vapor form during patties frying step. Arise query was to know how structural consolidation occurred. It seemed easy to think that, because of its high solubility, the added sugar water deprived part of starch granules or other contained carbohydrates in dough. So, it prevented starch granules coating and water logging and, subsequent gelatinization or essential fragility to reach sought convenient level giving low breaking force. Furthermore, salt had more affinity for water than for constituent carbohydrates of maize flour. By seizing solid matrix's free water to dissolve, some starch granules would not also find required water amount to gelatinize. Structural light consolidation due to salt actions was subs equently reinforced by added sugar substantial one.

Analysis of the recorded sensory characteristics: Results of the performed sensory tests on studied six (06) variants maize patties were illustrated on Figures 9, 10 and 11.

Data Analysis for Tested Colors: From patties color data analysis, as perceived by surveyed tasters, it might be retained that maize patties variants disclosed (Figure-9) various colors, ranging from "Ordinary known color" for witness(MPW00) to "Highly caramelizing color" for normal ratio salted (1.8%) and sugared (25%) wt/wt.mix ($MPSS_{25}$). These results clearly revealed that, as added sugar percentages to seasoned maize dough increased, patties caramelizing color intensified, as this could already be partly viewed on the selected four (4) variant patties samples of Figure-3.
This caramelizing status of added sugar too seemed to confirm the brought plastifying–reinforcement actionsto patties'solid structure and subs equently justified this breaking strength increase as acquired from mechanical testing the studied variants maize patties.

Patties Crustiness According to Respondents: Figures-10 (10.1-left and 10.2-right) exposed the partial taste testing results to classify the studied six (06) patties variants in relation with their offered crustiness only (C_{Ap}) according to tasters appreciation. These survey's results showed that, not added sugar patties' variants MPW00 and $MPSS_0$ were both two deemed most crusty by tasters. Unsalted variant MPW00 finished first, with cumulative score of 145/200 against 120/200 for salted, but without added sugar ($MPSS_0$). The four (04) other variants added sugar patties ($MPSS_{10}$, $MPSS_{15}$, $MPSS_{20}$ and $MPSS_{25}$) scored relatively low cumulative notes, showing that they became less crusty as their added sugar ratios increased. Undeniably, sugar incorporated variants maize patties grew relatively hard and difficult to break under teeth. These sensory testing results came to confirm the provided mechanical data from Texture-Analyzer measurements. They moreover reinforced the advanced earlier assertion stipulating that, added sugar really contributed to some structural plasticization - consolidation for corresponding variants maize patties.

One might also say that, such results indirectly well corroborated the obtained ones elsewhere. By means of Differential Scanning Calorimetry (DSC) analysis, an increase in the glass transition temperature had been recorded for starch gelatinization following sugar addition to the starch suspension[38]. By this ways, these authors registered a proof of structural consolidation, through this resistance increase to gelatinization when sugar was added in mix with starch suspension. This observation has been then justified by the fact that, gelatinization of sucrose-starch mixture subsequently required input of extra energy to ensure breaking of the formed chemical bonds networks in comparison to that for starch suspension taken alone. Similar results have already been published on the behavior of gelatinization temperature for starch-sucrose mixture at various sucrose concentrations[39, 40].

patties, exclusively the four (04) sugared ones, versus the added sugar ratios(S_a, %), may be represented by following trend equation:

$$C_{Ap} = 198.6 \cdot \mathrm{Exp}\left(-0.3 \cdot S_a\right) \quad (13)$$

with a regression coefficient value of R^2=0.993.

Answers to question on the most beloved patties: In Figure-11were displayed results of cumulative ratings from evaluation sheets for the labeled "personal affection (/feel)" parameter of overall quality of the six (06) variants maize patties exposed to people who agreed to participate to the realized taste survey. Despite the involved complexity in realistic choice of human feel, in front of to test patties variants, these displayed data 0in Figure-11allowed concluding that, all these four (04) added sugar variants patties ($MPSS_{10}$, $MPSS_{15}$, $MPSS_{20}$ and $MPSS_{25}$), have collected higher scores in terms of attributed cumulative points (from 109 to 166 points for "Very Good beloved" set criterion) by survey responders than no sugar contain variants maize patties. Ultimately, it might be noticed from this taste test that, the most beloved patties, according to the surveyed forty (40) tasters, belonged to added sugar variants confectioned patties, showing that sweet taste has emerged from expressed personal feel by respondents. Illustration could be clearly observed on Figure-11 by considering, for example, case of leading notation expressed as "Very good beloved" patties variant matching to black colored bars.

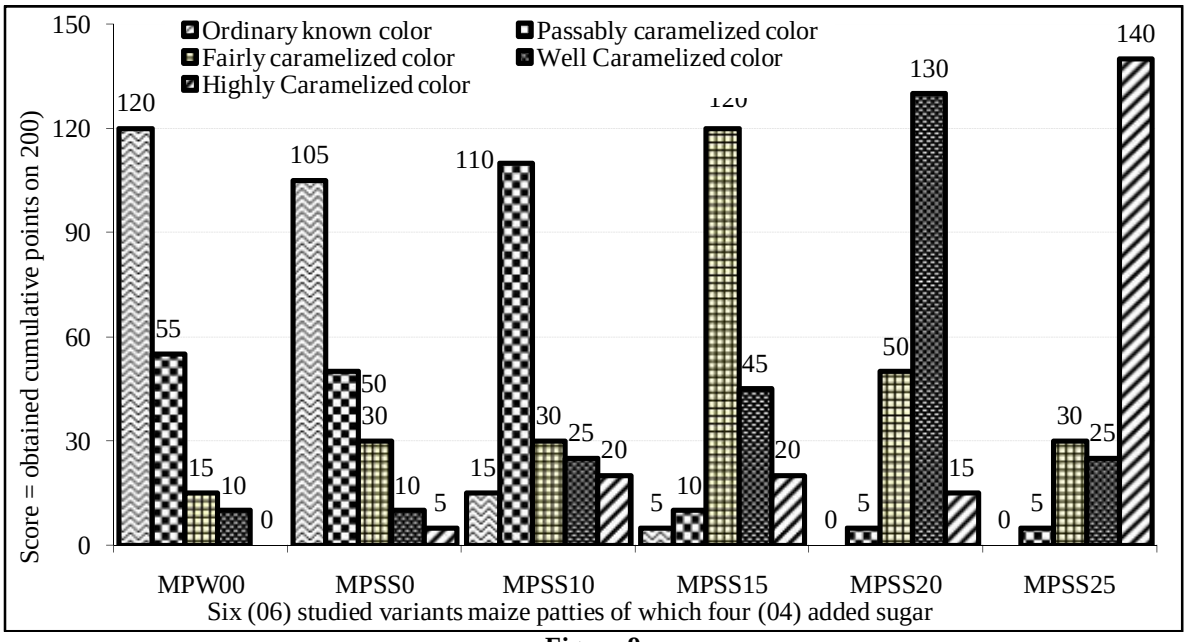


Figure-9

Color's cumulative gained scores of the six (06) studied variants maize patties according to surveyed fourty (40) respondents

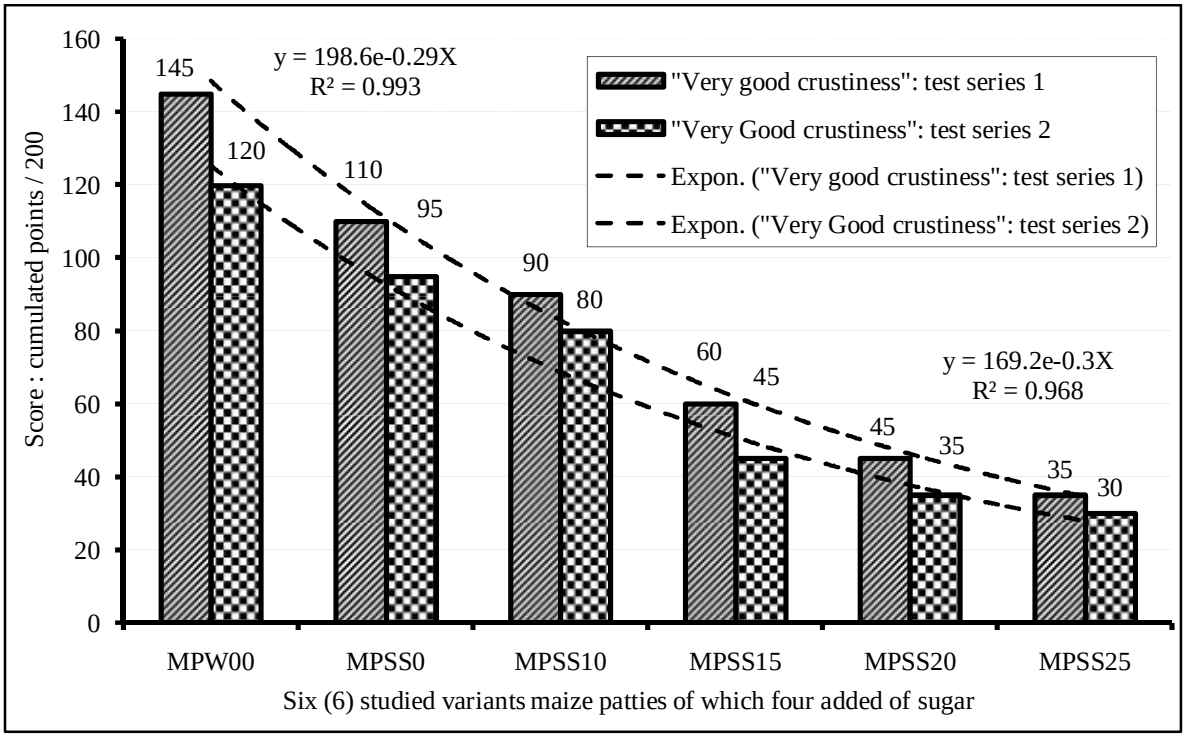


Figure 10.2- (in Excel Format)

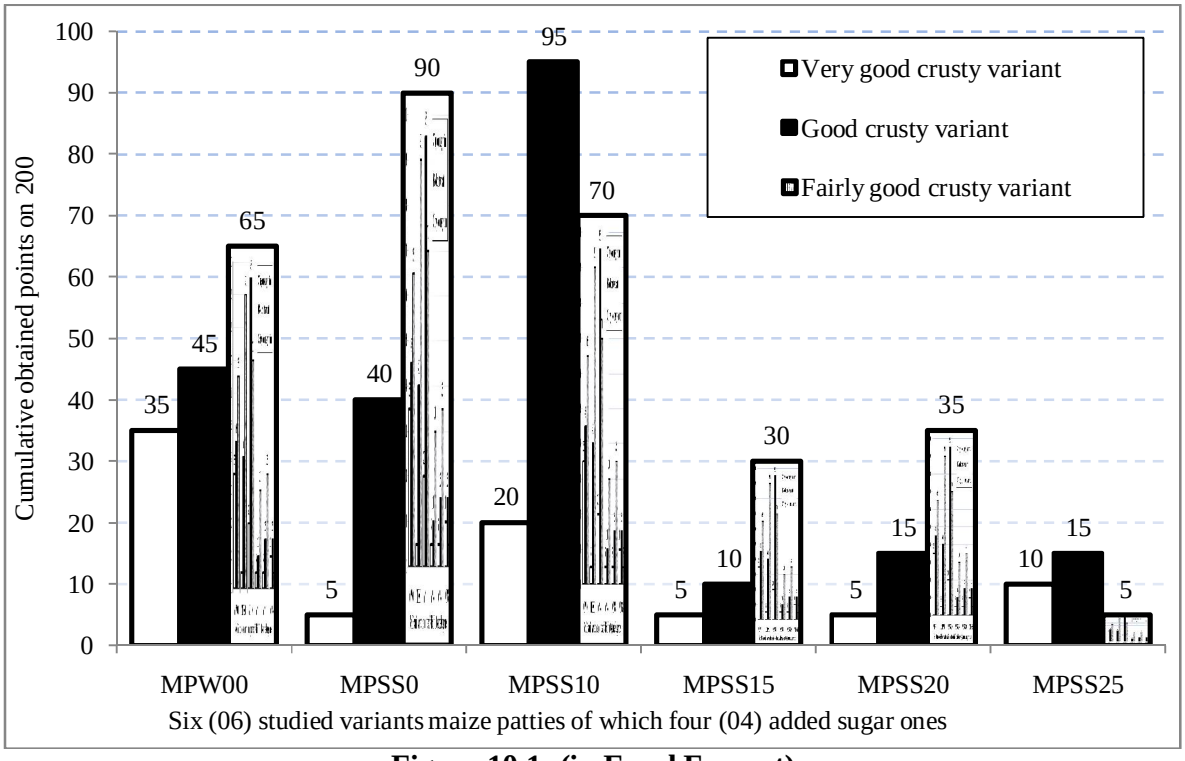


Figure 10.1- (in Excel Format)

Figures-10

Maize Patties crustiness assessment (10.1-Left: Cumulative notations distribution for crustiness appreciation. 10.2- "Good crustiness" versus added sugar ratio).

The mathematical function that adequately fits the data from developed colors (C_{AP}) by these studied six (06) variants maize There linked results seemed to be very consistent, revealing that, higher the added sugar ratio to patties formulation-manufacture, higher was reached cumulative score, corresponding to consumers first choice, although its bad crustiness level due to developed higher breaking strength by sugared variant of maize patties. This correlation did not hold again, if asked question dropped to consider case of "Good beloved patties" notation.

The answer to last question (Figure-11), according to recorded responders' results, systematically changed and oriented then towards the confectioned patties variant using normal salt ratio and no sugar added ($MPSS_0$) with a score of 102/200, followed far away by salted and 10% (wt/wt.mix) sugared made variant maize patties ($MPSS_{10}$) at score of 76/200.

Conclusion

This article allowed us presenting results of devoted investigation to some physicomechanical and sensory characteristics of formulated and manufactured six (06) maize patties variants rolled into sticks-like under the added sugar percentages influence's study.

Interesting results have been obtained showing that, more the added sugar ratio into formulation of seasoned maize dough increased, higher were resultant fried patties residual water content, bulk density, volume expansion ratio and breaking strength. Unluckily, this increase of breaking strength made the patties less crusty.

Results of the performed sensory tests also showed that, increasing the added sugar ratio had effects of intensifying the patties caramelizing color, whilst requiring consumers 'personal appreciation.

These overall study results were a first approach in characterization of the maize patties "ike/klaklou". Influences exploration of the degree of maize dough consistency, gelatinized starch's ratio after frying, and natural sweetening materials incorporation, in conjunction with study of process modeling and simulation, should lead to a better mastery of manufacturing process and then the patties quality improvement, to derive more income in field.

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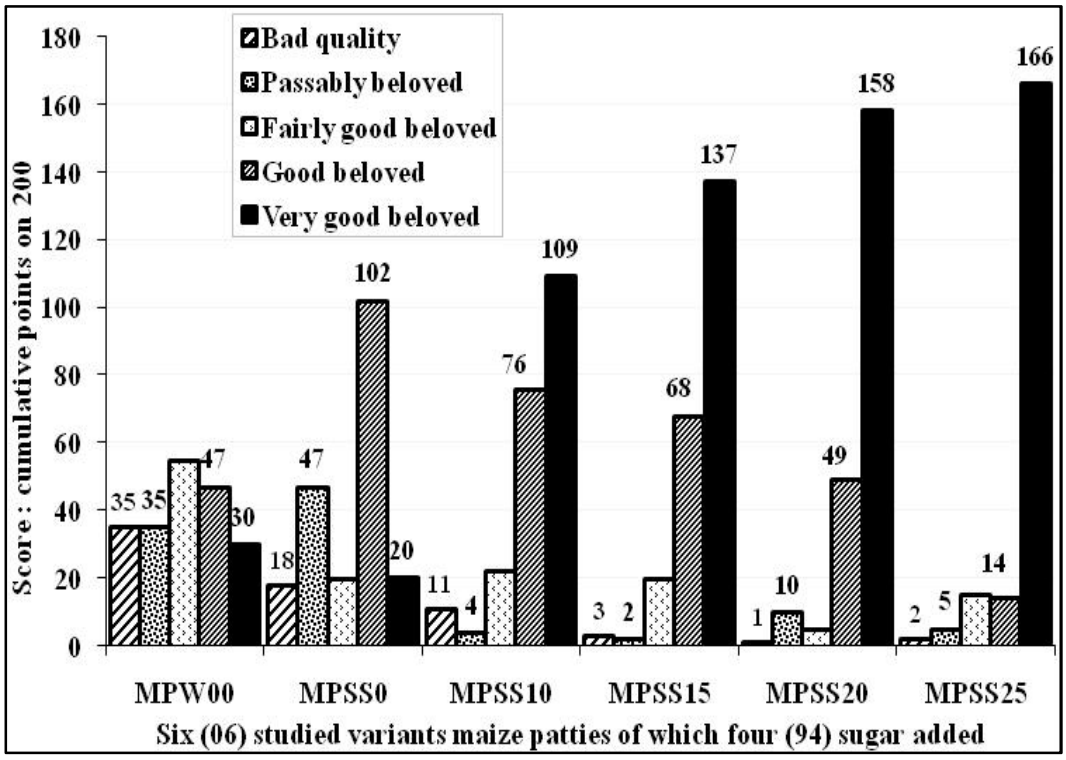

Figure-11
Surveyed tasters' personal affection for the studied six (06) maize patties variants

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