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Processing and Ingredient Effects on Quality Attributes of Maize Cereals

Er. Anshul Dhawan, Er. Parinder Kaur

Abstract*: *Snacks are a form of convenient light mealwith attractive taste and texture that not only engages the taste buds of the consumer but can also provide adequate nutrition. Snacks are usually consumed in between major meals. Flaked snack like breakfast cereals is also eaten either in the breakfast time or as an evening snack. However, the critical criteria for snack foods is that it should be attractive such that a consumer should buy again. Snack food industries are looking for attractive and innovative snacks that not only offer a good enjoyable product but also supplies lesser energy with improved nutritional status. Developing a shelf-stable snack food with grains as a major ingredient would require a processing technique with minimum loss of food grains. Breakfast cereal is one of the important and most convenient products which not only can serve as nutrient dense product but could also remarkably enhance the bio-availability of proteins, minerals and also significantly enhances its dietary fiber content. In the present study, the effect of processing i.e. flake making from grain parts (grits) or from grain flour, and final toasting condition such as moisture content of the raw grit flake or flour flake on the quality attributes of the flaked snack has been investigated. The CIE LAB instrumental color space parameters (L*, a* and b*), and the thickness of puffed of the snackshave been correlated with the sensory attributes of the products. The results presented have shown that maize grit based flakes are the best acceptable product with improved sensory and nutritional characteristics.

***Keywords* : compression energy, grit, shelf-stable, snack**

I. INTRODUCTION

Maize (Zea mays) is very important cereal grain. Maize cultivation is mainly prevalent in the tropical and subtropical region globally with a single or mixed cropping. Because of its high yield in compare to all other grains maize is said as the queen of cereals grains.The plants are able to grow up to atwo meters height and consists of a stem, and the grains growing on the cob. Having a high economic value maize grains have found use in different types of human food, fermented food products, beverages, animal and cattle feed, and is also being utilized as a major ingredient for production of various products like high fructose corn syrup, starch, ethanol, oil, cellulose and even in production of various plastics andfabrics. The global production of maize grain is dominant over other cereal grains. The worldwide production of maize is 960 MT in 2013-14 (Anon, 2016).

In India, maize production is holding the third position after rice and wheat with 23 MT in 2013-14. Maize is utilized in various industries for production of thousands of industrial products including starch, oil, protein, alcoholic beverages, food sweeteners, pharmaceutical, cosmetic, textile, gum, package and paper industries, etc. Starch being the main component of maize (maize flour) is a major food component of domestic products and many industrialized products. Maizestarch can be used in several novel techniques to manufacture many chemical products. Maize starch iseasily hydrolyzed leads to syrup production, mainly high fructose syrup, sweeteners and can also distilled grain alcohol by its fermentation with the help of enzymes. Traditionally methods utilize maize grain alcohol as the main source of Bourbon whiskey and beer. Another major use of maize is in production of maize oil and gluten.Maize kernels are consisting pericarp, germ, and endosperm. It has a good source of the water-soluble Vitamin B complex, dietary fiber and some essential minerals. It is also rich in carotenoids, such as pro-vitamin-A and beta-carotene.Maize contains protein which is indigestible and get exists while cooking. It is a lipid transfer protein, cause to a rare allergy in humans like skin rash, itching, diarrhea, vomiting etc.

Six types of maize are available based on the kernel composition (Paliwal, 2000; Darrah et al., 2003) :

- **Flint maize:**The kernels have a high percentage of hard endosperm around a small soft center.
- **Dent maize** is mostlyused for grain silage, the kernel mainly consists of endosperm and soft starch where endosperm is position in the corners and base of the kernel and the remaining is covered with soft starch.
- **Floury maize** is mainly bound of soft starch in endosperm which can be easily grinded and used into food products.
- **Waxy maize**is rich in amylopectin up to 70% in their starch.
- **Pop maize** contains a higher proportion of hard endosperm in their kernels compared to any other maize varieties. Making it suitable for consuming as a snack food.
- **Sweet maize**contains a higher amount of sugar due to their one or more recessive mutations reduce its conversion to starch.

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***** Correspondence Author

Er. Anshul Dhawan*,Assistant Professor, Food Technology, Department of Chemical Engineering, VFSTR, Guntur, India. Email: anshuldhawan0709@gmail.com

Er. Parinder Kaur, Assistant Professor, Food Technology, Department of Chemical Engineering, VFSTR, Guntur, India.

Generally, maize kernel consists of 80% endosperm and 10 to 11% germ (embryo) of the mature kernel dry weight, respectively of which 70-75% starch, 8-10% protein and 4-5% oil (Boyer and Hannah, 1994) is present. The endosperm is largely contained starch (~90%) while the germ contains high levels of fat (~33%) and protein (~18%). Starch is manufactured in plants as part of a mega-molecular assembly(James et al., 2003), it's granule consists of mainly two types of glucose homo-polymers amylose andamylopectin. Amylose consists of a linear chain of glucose units, connected by α-1, 4 glycosidic linkages.In amylopectin, the glucose molecules are of linked by α-1, 6 glycosidiclinkages (branching) and α-1,4 glycosidiclinkages in amylose. Protein in maize kernel is mainly in the form of storage protein i.e., 7S globulin(Monjardino et al., 2006). The embryo contains the highest amount of protein however since the endosperm occupies most of the kernel, it contributes to the most of the protein in maize (FAO, 1992). The proteins present in endosperm are prolamins/zeins contributing to 52% of the kernel nitrogen; glutelins constituting 25% of the nitrogen in kernel; albumins accounting 7% nitrogen and globulins upto 5%.Zeinspresent in endosperm cells are a rich source of amino acids like proline, leucine,glutamine and alanine but scarce in essential amino acids like lysine and tryptophan however embryo hashigher levels of these essential amino acid (FAO, 1992). Lipids are in comparatively higher quantity inembryo of the grains, especially in the scutellum. The embryo contains (~ 33%) oil while the whole kernel contains (~ 4%) oil (Dudley, 2007). Fatty acids in maize oil contains fatty acids in triacylglyceride form, the esterified form of hydroxyl groups of glycerol and occur as a mixture of saturated and unsaturated fatty acids (Boyer and Hannah, 1994). The high biological value of maize oil is due to high content of linoleic acid and low linolenic acid content.Toxic reactions from nitrate or nitrite poisoning in maize field may cause toxic effect in humans and animals. Maize plants or grain may also infect by mycotoxins produced by fungi. Nitrate poisoning may cause symptoms like abdominal pain, diarrhea, and salivation (Halpin and Hides, 2002). Maize is usually produced various types of food products and industrially processed products, which are using in our daily diet as a food or chemical products or beverages. Maize has anti-nutrient compounds such as phytate, tannins, etc. Maize also has enzyme inhibitors. Consumption of maize results in the reduction in risk of cardiovascular disease, inflammation, gastrointestinal cancer and other diseases. Maize products those are consuming by a human as a breakfast food, processed food, or beverages are flaking grits, maize rice, maize flour, maize flakes, maize oil, sorbitol, high sugar syrup, and pop maize, etc. Pop maize: Maize pop maize is very popular as they are tasty, easy to carry and are also nutritious. They are made by roasting (popping) maize and by adding salt, pepper etc. They are tasty and liked especially by children and youngsters. Maize flakes: Flakes are manufacturing directly from whole grain kernels or parts of maize, flakes are using as a ready-to-eat (RTE) processed food and consuming during breakfast usually with milk. Sugar and malt are added to improve Maillard reaction which adds colour, flavour to flakes.

Maize rice: Maize rice, also known as mealie rice. It is finely cut maize in which the bran and germ have been partly removed, and rest of kernels is using to produce "maize rice".

Breakfast cereal is one of the important convenience food commodities in everyday life. Among several breakfast cereals, toasted maize flakes in the form of flavour coated or uncoated is popular throughout the world. Ready-to-eat breakfast cereals are made from maize, wheat, oats or rice, usually with added flavor and fortifying ingredientsproduced for human consumption from processed grain which doesn't required further cooking (Fast, 1990).During producing ready-to-eat (RTE) maize flakes, toasting is a major step while processing, which helps in achieving the quality of the finished product and also to get correct and desired colour of flakes which helps in consumer acceptability. Initial moisture content also influences the final product quality especially texture and colour of the product. Also, processing methods and ingredient effects may have a role in obtaining the finished product quality. The systematic study on the processing effect of maize flakes and the effect of toasting of flakes is insufficient though the data are useful for standardization of the product. Hence, the objectives of the present investigation are to study the maize flakes prepared by different processing methods and to determine the effects of moisture content prior to toasting on important product attributes like colour, texture, puffed volume etc. and to relate with the sensory attributes like sensory texture and acceptability along with its surface characteristics of the product.

II. MATERIALS AND METHODS

Maize grit and flour

Maize grits were purchase from the local supermarket of Mysore, India and cleaned manually to remove the germ and graded to a particular (400 mesh) size.Maize grits were grounded to flour by using a laboratory grinder (Ika, Italy) and sieved through 60 mesh BS sieves.

Proximate Analysis

Proximate analysis of the sample was done as per AOAC method 2002. Moisture content was calculated in hot air oven at 105 °C for 5 h using 5 g of sample. Total ash content was estimated using 5 g of sample and igniting it in a muffle furnace at 550°C for 4 hours followed by a period of overnight cooling in muffle furnace after the sample has been sufficiently charred on suitable flame. The ash thus obtained was then analyzed for mineral content mainly zinc, iron and calcium against standard samples using atomic absorption spectroscopy. Crude protein was estimated using standard Kjeldahl method taking 6.25 as the conversion factor for nitrogen to protein. 5 g moisture free sample was used for fat estimation using Soxhlet apparatus using petroleum ether as a solvent for 18 hr at 65 °C. Total amylose content andsoluble amylose content was also estimated using spectrophotometric method at 630 nm after digestion with 1N NaOH followed by neutralizing with 0.1N HCl.

Preparation of ready-to-eat flakes

Ready-to-eat flakes were made using two different methods, from maize grit and from maize flour. Maize grits were soaked overnight followed by steam cooking and then drying in hot air oven to achieve the moisture content around 20%. The dried grits thus obtained were then flattened through roller flaking machine to form flakes and then again dried in hot air oven for different time intervals to get varied moisture content in the flakes and further analyzed.

Flakes from maize flour were prepared after steam cooking the maize dough prepared from grounded maize flour for 30 min. The cooked dough was then formed into small pellets and dried in hot air oven with were then pressed in flaking roller machine to form maize flakes which were further dried for different time intervals in hot air oven to get flakes at different moisture content. The flake samples then toasted in bakery oven (gas circulation) at 250°C for 30 s, cooled and packaged in polyethylene pouches for further analysis.

Colour Measurement

Colour measurement was done using a Hunter ColourLAB hand held colorimeter and values were recorded for both cases.

Bulk Density

Bulk density was measured using a measuring cylinder and calculating the ratio of mass to volume of the flakes prepared.

Texture Analysis

Hardness, work of compression and crunchiness we measured using textural analyzer for both the products thus formed.

III. RESULT AND DISCUSSION

Table I. Proximate composition of the maize grit flakes and maize flour flakes

	Maize grits flakes	Maize flour flakes
Moisture Content(%)	2.5±0.06	2.6±0.06
Protein (%)	8.5±0.4	8.6±0.5
Fat (%)	0.42±0.02	0.82±0.02
Ash (%)	2.4±0.3	2.5±0.2
Fe (mg/100g)	2.1±0.5	2.2±0.6
Zn (mg/100g)	5.5±0.4	5.3±0.6
Ca (mg/100g)	11.4±0.3	11.0±0.7

The nutritional composition of the toasted flakes and maize grits flour has shown in Table I. However, there is no significant variation in composition between the flakes. Both grit flakes and flour flakes have moderate amount of protein (8.5-8.6%) but low fat (0.42-0.82%). Both types of flakes show same amount of Fe, Zn and Ca as they were prepared from the same variety of the grain. The bulk density of toasted maize grit flakes varies between 193-289 kg/m3, and toasted maize flour flakes between 159-199 kg/m3, respectively.The crispness of the flakes depends on the bulk density of the final product. Because of the flour flake bulges more during puffing, they show less bulk density compared to the grit flakes. The L*, a* and b* values of the untoasted and toasted flakes have shown in Table II & III.The brightness of the sample is indicate from L*(lightness) values. Lightness values for toasted flakes ranges between 56-60 for maize grit flakes whereas56-63 for maize flour flakes, respectively. Lightness of the flakes depends on the moisture, temperature and time of toasting. This means too high levels of moisture content decreases the lightness of the final products of the flakes. The a* values of the flakes is an indicatorof the redness and greenness quotient. The a* values for toasted flakes arebetween 8.8-11.7 for maize grit flakes whereas 6.6-8.6 for maize flour flakes. The a* values of the toasted flakes depends on the moisture content of the flakes. The redness of the flakes increases with increases in moisture content of the flakes and that lead to the darkness of the flakes. The b* values of the flakes indicates the yellowness of the flakes. The values of toasted flakes are 31-34.4 for maize grit flakes and 30.2-31.4 for toasted maize flour flakes, respectively. The b* values get decrease with increase in the moisture content of flakes. The ΔE of the flakes indicates the colour difference of the flakes; the ΔE values of toasted flakes are between 49.1-54.7 for maize grit flakes, and 46.2-51.3 for corn flour toasted flakes, respectively. The ΔE values of the flakes depends on the moisture contents of the samples, if moisture too high the flakes becoming darkish after toasting. The importance of sensory assessment is of critical importance from point of view of consumer acceptability of the product. The sensory texture of the toasted flakes is shown in Table IV&V. The sensory texture are scored by using hedonic scale of 9 points (9: best, 5: acceptance, 1: worst) where the acceptability point is consider from 5. The sensory texture values for the toasted maize grits flakes are 5.0-9.0 and for maize flour flakes are 5.0-7.0, respectively. The sensory texture of the flakes are depends on the moisture levels of the flakes. At low moisture levels the sensory texture of the maize flakes is more and for the flour flakes at high moisture levels texture is more due to degree of gelatinization. Attractive appearance or colour is of prime importance for the acceptability of a food product. The sensory colour of toasted flakes is shown in Table IV&V. Scoring of sensory colour is done for the toasted flakes by using a 9 point hedonic scale (9: best acceptable, 5: limit of acceptance, 1: least acceptable) with 5 as the limit of acceptability. Maize grit flakes show colour score of 5.5-8.7 and for flour flakes are 5.0-6.5, respectively. The colouris directly proportional to the initial moisture content of the flakes before toasting. To achieve a better appearance of the toasted flake, the initial moisture content of the untoasted grit flake should be kept at low (10-12%) whereas for untoasted flour flakes the moisture should be high enough (above 20%) to puff the flakes. Table IV&V shows the scores of the sensory overall acceptability for toasted flakes. The higher value of overall acceptability indicates the high acceptability of the productby the customers. The more soft crispy the product, more small cracks are there in the curve.

Toasted grit flakes beingcrispier show highest consumer acceptability.

Table II. Characteristics of maize flakes from grits after toasting at different moisture

Moisturecontent of rawflakes(%) wb	Bulk density (kg/m^3)	Thickness (mm)	L*	a*	b*	ΔE
19.8±0.1	240.0±0.7	2.1±0.3	56.0±0.5	11.7±0.6	34.4±0.5	54.7±0.1
18.5±0.1	277.0±0.7	2.4±0.1	59.2±0.3	10.8±0.0	33.0±0.4	51.3±0.3
18.2±0.1	289.4±0.0	2.6±0.6	60.6±0.0	9.9±0.5	32.9±0.1	50.1±0.5
15.8±0.1	275.0±0.6	2.8±0.2	60.3±0.0	10.3±0.3	33.5±0.3	50.8±0.7
15.2±0.0	264.5±0.3	3.0±0.2	59.9± 0.6	9.7±0.6	31.0±0.7	49.3±0.9
14.3±0.0	238.3±0.8	3.1±0.7	58.6± 0.3	9.5±0.0	31.1±0.4	50.3±0.4
8.6±0.3	193.0±0.3	3.3±0.3	60.0± 0.1	8.8±0.6	31.1±0.4	49.1±0.3

Where, L*- brightness, a*- blue and yellow, b*- red and green, ΔE- colour difference

Table III. Characteristics of maize flakes from flour after toasting at different moisture

Moisture content (%) wb	Sensory texture		
	Texture	Colour	Overallacceptability
21.0	7.0±0.2	6.5±0.1	6.7±0.2
16.6	6.5±0.3	5.7±0.3	6.1±0.3
12.9	5.5±0.1	5.5±0.2	5.5±0.1
9.1	5.0±0.4	5.0±0.3	5.0±0.3

Table IV. Textural and sensory characteristics of the toasted grit flakes at different moisture content

Moisture content (%) wb	Sensory of texture		
	Texture	Colour	Overall acceptability
19.8	6.0±0.2	6.2±0.1	6.1±0.1
18.5	6.5±0.3	6.5±0.4	6.5±0.3
17.2	5.5±0.1	5.5±0.3	5.5±0.2
16.1	5.0±0.2	5.7±0.1	5.3±0.3
15.2	5.2±0.4	7.0±0.2	6.1±0.3
14.3	7.5±0.2	6.5±0.3	7.0±0.2
9.6	8.5±0.1	8.6±0.2	8.6±0.1

Where, L*- brightness, a*- blue and yellow, b*- red and green, ΔE- colour difference

Table V. Textural and sensory characteristics of the toasted flour flakes at different moisture content

Moisture content (%) wb	Sensory texture		
	Texture	Colour	Overallacceptability
21	7.0±0.2	6.5±0.1	6.7±0.2
16.6	6.5±0.3	5.7±0.3	6.1±0.3
12.9	5.5±0.1	5.5±0.2	5.5±0.1
9.1	5.0±0.4	5.0±0.3	5.0±0.3

VI. CONCLUSION

Grain based flaked snacks made using maize grits and flour is nutritionally better food with low calorie. There is no significant variation in the nutritional composition of the grit flakes and flour flakes. The studies indicate that lower levels of moisture give the best puffiness in the maize grit flakes and for flour flakes, higher moisture give the best puffiness. Colour intensity of the flakes increase with increase in initial moisture of the flakes before toasting. Low moisture toasting of grit flake gives best acceptability of snack due to its puffed thickness and crispness whereas, for flour flake high moisture is needed to achieve the best puffing. On toasting, the flakes show a porous microstructure that increases its thickness. The results presented in this investigation have shown that maize grit based flakes with improved sensory and nutritional characteristics can be prepared.

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AUTHORS PROFILE

Mr. Anshul Dhawan is M.Tech in Food Technology and Management from National Institute of Food Technology Entrepreneurship and Management. He has completed research on "**By-product utilization of soymilk waste okara and development of functionally enriched aloo bhujia".** He is currently working as an assistant professor, in department of food technology, Vignan's foundation for ScienceTechnology and Research, Guntur, India.

Ms. Parinder Kaur is M.Tech. in Food Technology and Management from National Institute of Food Technology Entrepreneurship and Management. She has completed research on "**Shelf-life Extension of Tomatoes using Polyvinyl Acetate as a Coating Material".** She is currently working as an assistant professor, in department of food technology, Vignan's foundation for Science, Technology and Research, Guntur, India.