"DEVELOPMENT OF TORTILLA AND CORN CHIPS FROM INDIAN MAIZE"

Thesis

Submitted to the Punjab Agricultural University
in partial fulfilment of the requirements
for the degree of

MASTER OF SCIENCE
in
FOOD TECHNOLOGY
(Minor Subject : Biochemistry)

DUPLICATE

By

Rupinder Jit Kaur Dasaur
(L-99-A-51-M)

Department of Food Science and Technology
College of Agriculture
PUNJAB AGRICULTURAL UNIVERSITY
LUDHIANA - 141 004

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CERTIFICATE-I

This is to certify that the thesis entitled, "**Development of tortilla and corn chips from Indian maize**", submitted for the degree of Master of Science in the subject of Food Technology (Minor subject: Biochemistry) of the Punjab Agricultural University, Ludhiana, is a bonafide research work carried out by Rupinder Jit kaur Dasaur (L-99-A-51-M) under my supervision and that no part of this thesis has been submitted for any other degree.

The assistance and help received during the course of investigation have been fully acknowledged.

12.7.01

Major Advisor
[Dr.(Mrs) Savita Sharma]
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CERTIFICATE-II

This to certify that the thesis entitled, "**Development of tortilla and corn chips from Indian maize",** submitted by Rupinder Jit Kaur Dasaur (L-99-A-51-M) to the Punjab Agricultural University, Ludhiana, in partial fulfilment of the requirements for the degree of Master of Science in the subject of Food Technology (Minor subject: Biochemistry) has been approved by the student's Advisory Committee after an oral examination on the same in collaboration with an External Examiner.

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ABSTRACT

The recipe and process of production of tortilla and corn chips were standardized using different maize varieties (Sheetal, Parbhat, Partap-I and JH-4193). The process of nixtamalization was standardized using 1.5% alkali and 300% water for cooking (both on corn basis), steam cooking for 20 min, steeping for 20 hr at 30–40^{0}C, washing and grinding to obtain masa. Dry masa flour was prepared by drying coarse masa at 30-40°C for 12-14 hrs to get moisture content of 9-10%. Different variables for production of quality tortilla and corn chips studied were suitability of maize variety, particle size of dry masa flour (50-100μ and >100μ), sheeting thickness of chips (0.05, 0.1 and 0.2 cm), baking temperature and time for tortilla chips (200, 240 and 280°C for 1, 2, 3 and 4 min), frying temperature and time (180°C for 1, 2 and 3 min; 190°C for 1, 1.5 and 2 min; 200 and 210°C for 0.5, 1 and 1.5 min), different shapes of chips (rectangular, square, triangular and circular) and different seasonings (salt, cumin, celery and mixed

seasonings).Storage study was done in aluminium foil laminated and polyethylene packs (0, 1, 3, 5, 7, 9 and 11 weeks). The best combination of all variables was chosen on the basis of organoleptic evaluation. Sheetal was the best among all varieties. Products prepared with fine particle size (50-100μ) of dry masa flour were better in quality. The chips sheeted to 0.05 cm thickness, cut to small rectangular shapes, baked at 240°C for 2 min (for tortilla chips), fried at 190°C for 1.5 min and sprinkled with mixed seasonings scored highest for all sensory attributes and produced good quality chips. Tortilla chips and corn chips remained acceptable upto 11 weeks of storage in both of the packaging materials at room temperature (28-37°C).

12/7/01

Signature of Major Advisor

Rupinderjit Kaur 12/7/01

Signature of the Student

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Chapter I

INTRODUCTION

Snack food consumption and demand is rapidly rising worldwide. "Snacking" is being described as the problem free consumption of - easy to handle, miniature portioned, hot or cold products in solid or liquid form which need little or no preparation, and are intended to satisfy the occasional pangs of hunger. (Tettweiler, 1991) The demand of the snack foods is increasing because of changing food habits, shortage of time and advent of new convenient foods in the market with numerous varieties.

Snack foods are categorized into hot snacks and cold snacks (milk and dairy products; bakery products; bars; savory products and other products). The prospects for the worldwide development of savory snacks-the largest of the snack food sectors – are rated as extremely positive. These snacks include chips (crisps), sticks, extruded products, crackers, pretzels, salt sticks, nuts and nut mixtures (Tettweiler, 1991). According to Snack Food Association, potato chips are still the leading salted snacks in nearly every region of US, but tortilla chips and corn chips are increasing in popularity. The primary products of the corn snack food market include tortilla chips, corn chips, some extruded products, corn flakes and popcorn

etc. Americans consumed 3.48 billion pounds worth of salty snacks including potato chips, tortilla chips, corn chips, extruded and fabricated chips and multigrain chips (Shukla, 1994).

Tortilla and corn chips are Mexican corn products, which involve the ancient Aztec process of nixtamalization (Gomez *et al*, 1987). Tortillas, tortilla chips and corn chips have gone from being an almost exclusively Spanish food to being a highly accepted food across America with increasing importance world wide (Rooney and Suhendro, 1999). In Mexico, 80% of the total production of corn is channeled for human consumption mainly as tortillas, 15% as feed and only 5% is processed as corn syrup, dextrins, starch and other products (Perez-Villasenor, 1986).

In Indian food industry, corn has a very wide scope of its utility. The over dependence of Indian farmers on paddy-wheat rotation had made them realize that the potential yield of these two crops cannot be increased beyond their present status. Other factors such as over exploitation of ground water and decline in soil fertility due to this repeated rotation has already rang the alarm bell. Resultantly, in present scenario a need for diversification is seriously felt. The best alternative of the diversion can be the coarse cereals of which maize has the best scope to offer. Being cheaper than rice and wheat, it not only serves as food for the poorer sections of the

population, but also as animal feed. Its utility is nearly 100%, out of which nearly 90% is used directly as food. Maize as food is chiefly used in the form of *chapaties*, various forms of porridge, as green and roasted ears and as popcorns. It is milled to get various products such as pure starch, gluten, germ by wet milling and flaking grits, coarse grits, maize meal, flour, oil and hominy by dry milling (Singh and Izuno, 1982).

A variety of snacks can be prepared from maize. For example tortillas, tortilla chips, corn chips made from alkali-treated corn dough, corn flakes, corn muffins, creamed corn etc. These snack foods have become a prime target of some consumer advocates and nutritionists who have referred them as sources of 'empty calories'. But reality is that these snacks provide instant energy, as they are rich storehouse of nutrients.

Corn snacks are rarely available in India. Due to urbanization, the life style of Indian people is also changing. The consumers are looking for new recipes and products on grocery shelves. Keeping in view the composition of Indian maize varieties, tortilla chips and corn chips can be prepared from them. Also Indian consumers have versatile taste, so these products will be readily accepted in Indian market.

Tortilla chips and corn chips are rich in B-vitamins and proteins. Calcium content of these products is also high because of alkali-treatment known as nixtamalization. This process includes cooking and soaking maize in water containing lime, which softens the pericarp, endosperm and gelatinizes the starch (Rooney and Suhendro, 1999). The alkali treatment also helps to break niacytin complex to release bound niacin to free form (Ranum, 1997).

Tortilla and corn chips differ in process of production. Corn is cooked in alkaline water. The cooked, steeped corn called nixtamal is washed to remove loose pericarp and residual lime. The nixtamal is ground to masa, which is kneaded. For corn chips, after extrusion or sheeting and cutting of masa, immediate frying is done. For tortilla chips masa is sheeted and cut. Then baked or dried conditioned for sometime and then fried (Gomez *et al*, 1987).

Tortilla and corn chips can also be prepared from dry masa flour. This flour is obtained by grinding the masa and flash drying it. Then sieving, regrinding the coarse particles and sieving again. Then particles are reformulated into correct particle size distribution (Rooney and Suhendro, 1999). Increased cost, lack of flavor, poor textures in products prepared from dry masa flour are the major disadvantages (Gomez *et al*, 1987).

Tortilla chips and corn chips have very bright prospects in near future in India. So we are making an attempt to develop tortilla and corn chips from Indian maize. The main objectives of study are:

1. To standardize the recipe for preparation of tortilla and corn chips.
2. To standardize the method of preparation.
3. To assess the quality and acceptability of product.
4. To study the packaging requirements in relation to storage.

Chapter II

REVIEW OF LITERATURE

Mexican food products such as tortillas, tortilla chips and corn chips are made from corn by nixtamalization process, which involves alkaline cooking, steeping, washing and stone grinding of the kernels to produce masa. Corn masa is kneaded and moulded, then baked on a hot griddle and fried for tortilla chips, frying immediately after moulding for corn chips or dried to produce nixtamalized corn flour (Serna-Saldivar *et al,* 1990).

Perusal of literature reveals that no work has been done on tortilla and corn chips in India. Most of the work done on these Mexican snacks has been patented in the US. The relevant literature available on maize, tortilla and corn chips is discussed under the following heads:

2.1 Composition of Indian maize.

2.2 Nixtamalization.

2.2.1 Basic process.

2.2.2 Chemistry.

2.3 Dry masa flour.

2.4 Tortilla and corn chips – Process of production.

2.5 Nutritional aspects.

2.1 Composition of Indian maize

Gupta *et al* (1984) studied the chemical composition of maize kernels and their products and observed that germ was the richest source of fat, protein, ash and crude fiber.

According to Indian Agricultural Research Institute report (1980), the nutritional quality of maize protein was poor because of limiting concentration of two essential amino acids, viz., lysine and tryptophan, and high leucine content. The protein content in maize varieties varied from 8.5 to 13.6 per cent, while the average was about 10% Lysine content varies from 1.7 to 3.2% while tryptophan from 0.35 to 0.5%.

Gupta *et al* (1987) observed that protein and starch contents in Indian maize ranged from 9.85 to 12.91 and 64.33 to 70.57 per cent, while the ranges in values of fat, ash and crude fiber contents were 4.33 to 5.89, 1.35 to 1.92 and 2.18 to 2.91 per cent, respectively. They also reported that incorporation of opaque-2 gene in normal maize varieties could favorably modify the amino acid composition of the endosperm primarily due to reduction in the zein fraction of protein, which was largely deficient in the lysine and tryptophan.

Rehal (1997) reported that percent protein, fat and starch in maize ranged from 9.00-11.30, 3.33-4.41 and 56.65-60.97 respectively.

2.2 Nixtamalization

2.2.1 Basic process

Khan *et al* (1982) laid emphasis on the replacement of traditional corn-cooking procedures by large-scale commercial operations in which corn was cooked and ground immediately with little or no steeping.

Gomez *et al* (1987) discussed the traditional method of nixtamalization or alkaline cooking. It began by cooking whole corn in excess water with 1% hydrated lime near boiling with frequent stirring. Then it was steeped overnight and washed to remove pericarp and residual lime. After grinding the nixtamal to masa, it was kneaded, moulded and then baked to get tortilla.

Morad *et al* (1986) reported that alkaline cooking increased the amount of calcium in tortillas. Soaking softened the seed coat and thus reduced cooking time.

Serna-Saldivar *et al* (1991) analyzed that alkali used in the process caused partial or total loss of pericarp and the extent of this

loss depended on type of alkali, its concentration, cooking time and temperature.

Serna-Saldivar *et al* (1993) reported that the most important control factor was the degree of cooking as it greatly affected masa machinability, product properties and yield. Ramirez-Wong *et al* (1994) discussed that masa texture, which was very critical aspect for quality and determined by masa variety, endosperm texture and type, drying conditions and soundness of grains.

Excess cooking could increase dry matter losses that resulted in lower products yield and loss of nutrients (Almeida-Dominguez *et al* 1998). While studying the effects of nixtamalization, Rooney and Suhendro (1999) described that cooking corn in lime softened the pericarp and endosperm, starch and protein matrix was hydrated and a small amount of starch was gelatinized. Washing removed part of pericarp, leached solubles and the excess lime.

2.2.2 Chemistry

Protein losses of 35%,24% and 28% of the total dry matter lost during cooking with traditional, pressure cook and commercial methods respectively, were observed by Khan *et al* (1982).

Morad *et al* (1986) carried out investigations and reported that presoaked corn contained more calcium after 12 hr of steeping compared to 80 min of cooking in traditional method. As cooking

time increased, more starch became susceptible to enzyme attack. Pflugfeldar *et al* (1988) reported losses of starch birefringence during commercial nixtamalization of corn, i.e., more than 47 % loss of birefringence was found in coarse masa made from soft endosperm under severe heat treatment. Gomez *et al* (1992) described that the nixtamalization also caused swelling and agglomeration of starch granules in endosperm. Grinding the nixtamal caused complete physical disruption of kernels resulting in dispersion of starch granules.

Moreira *et al* (1995) observed that frying of tortilla chips was characterized by starch gelatinization and formation of a dark yellow crust due to Maillard reaction, a reaction between a reducing sugar and an amino acid. In tortilla chips, most of the starch gelatinization occurred during baking and at early stages of frying.

Rooney and Suhendro (1999) reported that lime acted on cell wall and converted the hemicellulose into soluble gums, starch gelatinized, part of lipids got saponified, released the niacin from the niacytin complex and solublised part of the proteins that surrounded the starch granules. Starch chains were charged which slowed the retrogradation and retained freshness of tortillas.

2.3 Dry masa flour (DMF)

Bazua *et al* (1979) gave a procedure in which dry raw corn was ground in a cereal grinder and combined with powder calcium hydroxide and fed in an extruder with controlled flow of cold water to get masa which was dried to get dry masa flour.

Montemayor (1986) recommended the use of corn masa flour as it improved product uniformity, puffing and oil absorption characteristics and problems of storing corn were also removed. Gomez *et al* (1987) reported that preparation of corn snacks from dry masa flour required 30-40 min as compared to 12-24 hr process of preparing masa. The masa was dried, ground, sieved and blended to yield a shelf stable product of desired particle size with optional addition of nutritional supplements.

Stauffer (1993) had described the advantages of DMF which included: elimination of capital costs of cooking, washing and grinding equipment, avoidance of the problems associated with high solids, high biological oxygen demand (BOD) waste water. Also the variability in the product was minimized thus, improving the consistency of end product.

Almeida-Dominguez *et al* (1996) investigated that nixtamalized corn flour (NCF) was a product of controlled grinding and particle

size formulation of corn that had been cooked in the presence of lime. Fine flours were used for soft tortillas while coarser ones for tortilla chips, corn chips and other fried products.

Martinez-Flores *et al* (1998) observed that extruded masa flours had good adhesiveness and no problems of stickiness. Smaller particles were responsible for most of the water uptake, viscosity, cohesiveness, plasticity and smoothness. Arambula et *al* (1998) gave a method which involved the extruded pellets of masa that were dehydrated in a tunnel dryer to get moisture content of 8-10% (w/w). The dry masa was reground to get instant corn flour.

Rooney and Suhendro (1999) reported that major disadvantages of DMF were the high price of the product, loss of flavor and poor texture of products prepared from DMF.

2.4 Tortilla and Corn chips: Process of production

Stauffer (1983) gave a method to make corn chips in which masa was extruded through a slit to gave a ribbon of dough which was cut off by a knife. The raw chip fell into hot fat for deep-frying. For tortilla chips, the masa was rolled out into a thin sheet, cut into desired shape and baked. Then tempered to equilibrate moisture and stress throughout the chip. Finally, they were very briefly deep-fried to create a crisp texture, salted or seasoned and packed.

Gomez *et al* (1987) described the difference in tortilla chips and corn chips. According to them, tortilla chips were baked so they had a firm texture, whereas corn chips were generally more friable because the water vapor puffed the chips slightly as it escaped during frying. Tortilla chips had finer particles whereas corn chips, coarse particles.

Bello *et al* (1991) reported that excess water in the formula resulted in sticky dough. Undermixing of dough gave non-uniform baked products and overmixing resulted in sticky dough. Herrera (1997) analyzed that the original tortilla chip was made from a tortilla. Tortilla and tortilla chips were sheeted, baked, equilibrated and then fried. Moisture values after tempering were 35-37% by weight and 1 –2 % by weight after frying. For corn chips moisture content after frying was also 1-2%. Oil levels of tortilla chips were between 22-25% and corn chips was 30-40%. Tempering of tortilla chips permitted even oil absorption, less blistering during frying and attractive final appearance.

Hix (1998) observed that quality of the chips depended on the corn and the way it was cooked. If the corn kernels were too small, cracked or broken or moisture was too high, the chips expanded too much during frying and absorbed excess oil. If cooking time was less

or moisture was too low, the chips tended to be hard, dense and low in fat.

Taylor *et al* (1998) described that control of moisture content prior to packaging was important for maintaining the quality of shelf stable tortillas. High moisture content could lead to mold growth. While low moisture content caused product brittleness and cracking.

Two stage frying process involved two steps (Baker *et al*, 1998). First baking was done and then the proofed pieces were par fried in oil in a mono-layered array. Then they were finished fried to desired moisture content. Chips were then exposed to superheated steam to partially remove the oil from the surface of the chip.

Deis (2000) reported that proper thickness of different products was 0.10 inch for standard restaurant "table" tortilla chips and 0.03 inch for a tostito-type snack chip. Chips were baked for 15-30 sec at 575^0 to 600^0 F. Its crispness, color, mouthfeel, consistent flavor and appearance judged the quality of chip. Lower oil chips were tough and had poor mouthfeel, and over oiled chips tasted very greasy. He also reported that different flavors could be added in the chips e.g. nacho cheese, lime, roasted garlic, chili and lime, garlic and vinegar, fresh tomato etc.

2.5 Nutritional aspects

Kent (1983) reported that the disease pellagra due to deficiency of niacin was prevalent among people who relied upon maize for a large proportion of their daily food. Some 50-80% of niacin in maize occurred in a bound form as niacytin, which was biologically unavailable and rendered the maize deficient in niacin. Alkaline cooking broke this complex and made niacin free in the cooked grains and products.

Feria-Morales and Pangborn (1983) studied that since corn was deficient in lysine and tryptophan, it could be enriched with milk solids, soybean, oil seed flours, sorghum, germinated corn, potatoes and even cheese.

Matz (1991) investigated the physical and chemical losses of yellow corn. These were 65% in thiamin, 32% in riboflavin, 31% niacin, 33% ether extractables, 10% in nitrogenous substance and 21% in carotene originally present. The hot lime water treatment increased the rate of release of most of the essential amino acids so that masa was more nutritious than corn flour from which it has been made.

High fiber tortillas could be produced by adding 100g oat bran or rice bran (Friend *et al*, 1993) and protein content could be increased by adding vital wheat gluten.

Suhendro *et al* (1993) proposed that proteins from various sources could be added to the control tortilla dough to increase protein content by 3.1% and to improve amino acid composition of tortillas.

Alkaline corn processing method increased the availability of B-vitamins and proteins. Commercial alkali treatments could also significantly increase calcium content depending on number of washings and the type of alkali used (Deis, 2000). The chips fried in a heat stable non-digestible sucrose polyester known as olestra contained only 90 calories per oz. v/s 140 calories per oz. with the chips fried in regular oil.

Chapter – III

MATERIALS AND METHODS

An investigation on "Development of tortilla and corn chips from Indian maize" was carried out in the Department of Food Science and Technology, PAU, Ludhiana.

3.1 Material used in the investigation

3.1.1 Maize grains:

Four varieties of maize (Sheetal, Parbhat, PartapI, JH- 4193) were obtained from the Department of Plant Breeding, PAU, Ludhiana. The grains were properly cleaned and stored in PET jars for subsequent use in the investigation.

3.1.2 Salt and seasonings:

Common salt and other seasonings (cumin, coriander, black pepper, celery etc.) obtained from a local grocery store was used in the study.

3.1.3 Frying oil:

Refined oil (Sweekar, Sunflower oil) was obtained from a local grocery store.

3.1.4 Lime/Alkali:

$Ca(OH)_2$ of high purity was used for the alkali treatment.

3.2 Physico-chemical characteristics

3.2.1 Moisture:

Weighed samples of ground maize (2g) were dried in a hot air oven at 130 $\pm$ 1^{0}C for one hour and moisture content in per cent was calculated from the loss of weight (AACC 1990).

3.2.1 Crude protein:

Macrokjeldahl method was used to determine nitrogen and conversion factor of 6.25 was used to calculate per cent protein for maize grains, tortilla and corn chips (AACC 1990).

3.2.2 Ash:

Maize samples (10g) were incinerated in a muffle furnace at 540^{0}C for 5 hours and results expressed as per cent (AACC 1990).

3.2.3 Crude fat:

Weighed samples (5g) of ground maize were extracted with petroleum ether (boiling point 60-80^{0}C) in a Soxhlet apparatus for 16 hours. The extract containing fat and petroleum ether was evaporated over steam bath and dried in an oven at low temperature (50^{0}C), weighed and per cent fat was calculated (AACC 1990).

3.2.4 Sugars:

AACC (1990) method was followed to determine reducing and non-reducing sugars. Sugars were extracted from 5.675g of maize samples with acetate buffer followed by immediate addition of tungstate solution. Potassium ferricyanide method was used to estimate the reducing and non-reducing sugars and results were expressed as per cent glucose and sucrose respectively.

3.2.5 Starch:

Conversion of starch was done by addition of 100 ml water and 30 ml concentrated hydrochloric acid in 1g of sample of ground maize and boiling in water bath for 2.5 hours (Ranganna, 1994), cooled, neutralized and made to 250 ml.

After precipitating protein and heavy metals using lead acetate and potassium oxalate, the contents were filtered through No. 41 filter paper and total sugars were determined by Fehling solution method (Lane and Eynon, 1923).

Results were expressed using following formula:

$$\text{Total sugars (TS) (\%)} = \frac{\text{Fehling sol. equivalent x volume made}}{\text{ml of filtrate used x sample weight}} \times 100$$

$$\text{\% Starch} = (TS - FS) \times 0.9$$

FS – Free sugars

3.2.6 Particle size distribution:

Particle size distribution in different samples of ground maize was estimated by Benzene sedimentation method (Henry Simon, 1985). A weighed sample of maize flour (1g) was allowed to fall through benzene mass in the Simon sedimentation apparatus. The sedimentation values were recorded after 1, 1½, 2½, 3, 4, 6, 13, 53 min. and 2-hr interval or until clear and a constant value was obtained. The deposit values were expressed as percentage of the final reading and a curve was developed to indicate particle size distribution in different size range (microns).

3.3 Preparation of masa

The method for preparation of masa was standardized after conducting a number of trials. Variation of amount of alkali to be used (1, 1.5 and 2 per cent on grain basis), amount of water to be used for cooking (200, 250 and 300 per cent on grain basis), type of cooking (open pan boiling, closed pan boiling or cooking, pressure cooking), time of cooking (1½, 2 and 2½ hr for open pan boiling and 10, 20 and 30 min for pressure cooking), soaking time (16, 20 and 24 hr) variations were done. From these trials pressure cooked sample

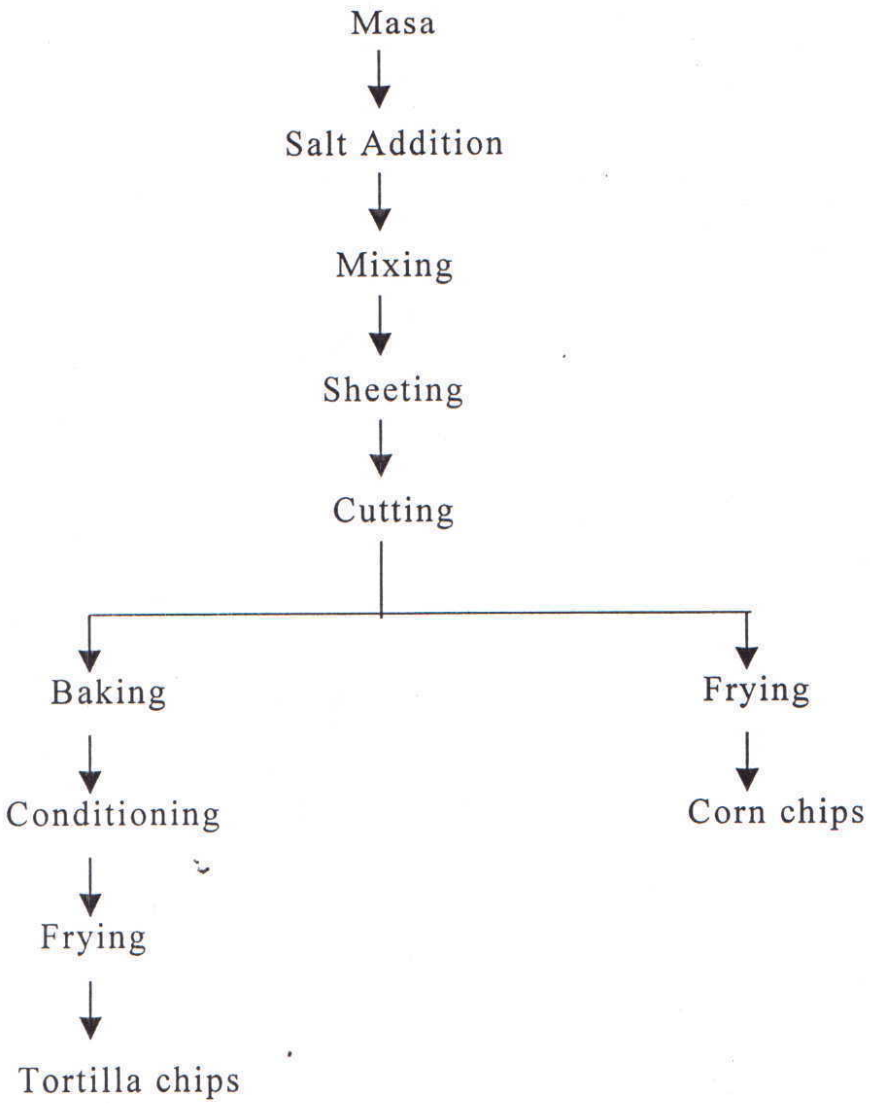
was chosen in terms of easy processing (pericarp removal), softness of grains and less gruel solids loss. The nixtamalized grains were then washed to remove pericarp and ground on stones to obtain masa.

3.4 Dry masa flour

The nixtamalized grains were coarsely ground and dried in the cabinet dryer at the temperature between 35-40^{0}C for 12-14 hrs to obtain a moisture content of 9-10%. The material was then ground in Cemotac lab mill to get fine and coarse flour at setting number 1 and 2 respectively.

3.5 Tortilla and Corn chips: Method of preparation

To the masa prepared earlier, 2 per cent salt was added by weight and mixed thoroughly. The tortilla and corn chips were prepared as per the flowsheet and method given by Gomez *et al* (1987) below:



3.5.1 Standardization of products using different variables

3.5.1.1 Suitability of varieties

Four varieties were taken; viz, Sheetal, Parbhat, Partap-I and JH-4193. Product was prepared using standard method and best variety chosen on the basis of sensory score and used for subsequent study.

3.5.1.2 Sheeting thickness

Masa was sheeted into three thicknesses – 0.05, 0.1 and 0.2 cm to study its effect on quality of tortilla and corn chips.

3.5.1.3 Baking temperature and time.

Tortilla chips were baked at 200, 240 and 280° C for 1, 2, 3 and 4 min. Best combination of these was worked out.

3.5.1.4 Frying temperature and time.

Best frying temperature and time combination were concluded on the basis of sensory quality of product. The different combinations used were as follows:

	Temperature (^{0}C)	Time(min.)
a)	180	1, 2, 3
b)	190	1, 1.5, 2
c)	200	0.5, 1, 1.5
d)	210	0.5, 1, 1.5

3.5.1.5 Different shapes of Tortilla chips

The product was prepared having different shapes i.e. small rectangular, big rectangular, square, triangular and circular and scored on the basis of organoleptic evaluation.

3.5.1.6 Different seasonings

Salt @ 2%, cumin @ 1%, celery @ 1%, mixed seasonings (black pepper powder, coriander powder @ 0.5% and salt @ 1%) levels were added and acceptability was worked out.

3.6 Packaging material

The product prepared was packed in aluminium foil laminated packs and polyethylene packs(100 gauge) and storage study was done for 1, 3, 5, 7, 9 and 11 weeks.

3.7 Final product evaluation

Finally, tortilla and corn chips were prepared using the best recipe based on standardized combination of variables. The products so prepared were subjected to organoleptic evaluation for different sensory attributes (Appearance, color, texture, taste, overall acceptability) using nine point Hedonic scale (Larmond, 1970).

3.8 Expression of results

Analytical results were expressed at 14% moisture basis for comparison of maize grains, tortilla chips and corn chips

composition. Sensory score (out of 9.0) was the mean of scores by six semi trained panel members.

3.9 Statistical analysis of data

Data collected from the aforesaid experiments was subjected to statistical analysis with the help of factorial design (Steel and Torrie, 1960).

CHAPTER - IV

RESULTS AND DISCUSSION

Four maize varieties, Sheetal, Parbhat, Partap-I and JH-4193 were taken for the standardization of the recipe and the method of preparation of tortilla and corn chips. The results obtained are summarized in this chapter.

4.1 Proximate composition of maize grains

The proximate composition of maize grains of different varieties is given in Table 1. Variety JH-4193 had highest values of crude protein (12.80%) and starch (61.73%) followed by Sheetal and Parbhat. Partap-I variety had higher crude fat (3.69%), total sugars (5.17%) and reducing sugars (2.73%). Over all the protein content ranged from 11.74-12.80% with lowest in Partap-I. Crude fat and ash varied from 2.33-3.69% and 0.44-0.84% respectively with lowest in Sheetal for both. Starch and total sugars were in the range of 54.10-61.73% and 4.07-5.17% respectively. According to Gopalan et al (1992), the proximate composition (protein, fat, ash, starch and total carbohydrates) of Indian maize was 11.1, 3.6, 1.5, and 66.2 per cent respectively. The values obtained after the analysis of four varieties

Table 1: Proximate composition of maize varieties.

Characteristic	Variety			
	Sheetal	Parbhat	Partap-I	JH-4193
Crude Protein (%, N x 6.25)	12.65	12.55	11.74	12.80
Crude Fat (%)	2.33	3.67	3.69	3.13
Ash (%)	0.44	0.67	0.84	0.78
Starch(%)	58.64	54.61	54.10	61.73
Total Sugars (% (Glucose)	4.07	5.16	5.17	4.18
Reducing Sugars (% Glucose)	2.09	2.35	2.73	2.66
Non Reducing Sugars (%, Glucose)	1.88	2.66	2.31	1.44
*Other Constituents (%, approx.)	7.87	9.34	10.46	3.38

* Crude fiber, cellulose and hemicellulose etc.

falls approximately in this range. The values for protein, fat and starch in Parbhat variety were 8.55, 3.88 and 56.65 percent respectively (Rehal, 1997).

4.2 Standardization of Recipe

4.2.1 Nixtamalization process

After conducting the various trials using different variables (as described in chapter III, 3.3), the method of nixtamalization was standardized as given in the flowsheet (Fig. 1).

From the two methods used, first was the traditional method in which maize grains were boiled in open pan for different times using alkali [$Ca(OH)_2$] and water combinations. But the disintegration of grains during cooking for longer time and some difficulty in removing the pericarp when cooked for a lesser time, were the main problems. According to the traditional method, whole corn was cooked with water (120-300%, grain basis), lime (0.1-2.0%, grain basis) for 0.5-3.0 hr at a temperature of 80-100^{0}C, then steeping for 8-24 hr at variable temperatures. Washing was done to remove pericarp and excess lime (Gomez *et al*, 1987). In an alternative method corn, lime and water were cooked for one hour (boiling at 100°C for 35 min and then cooking at 85^{0}C for 25 min). Mixture was stirred

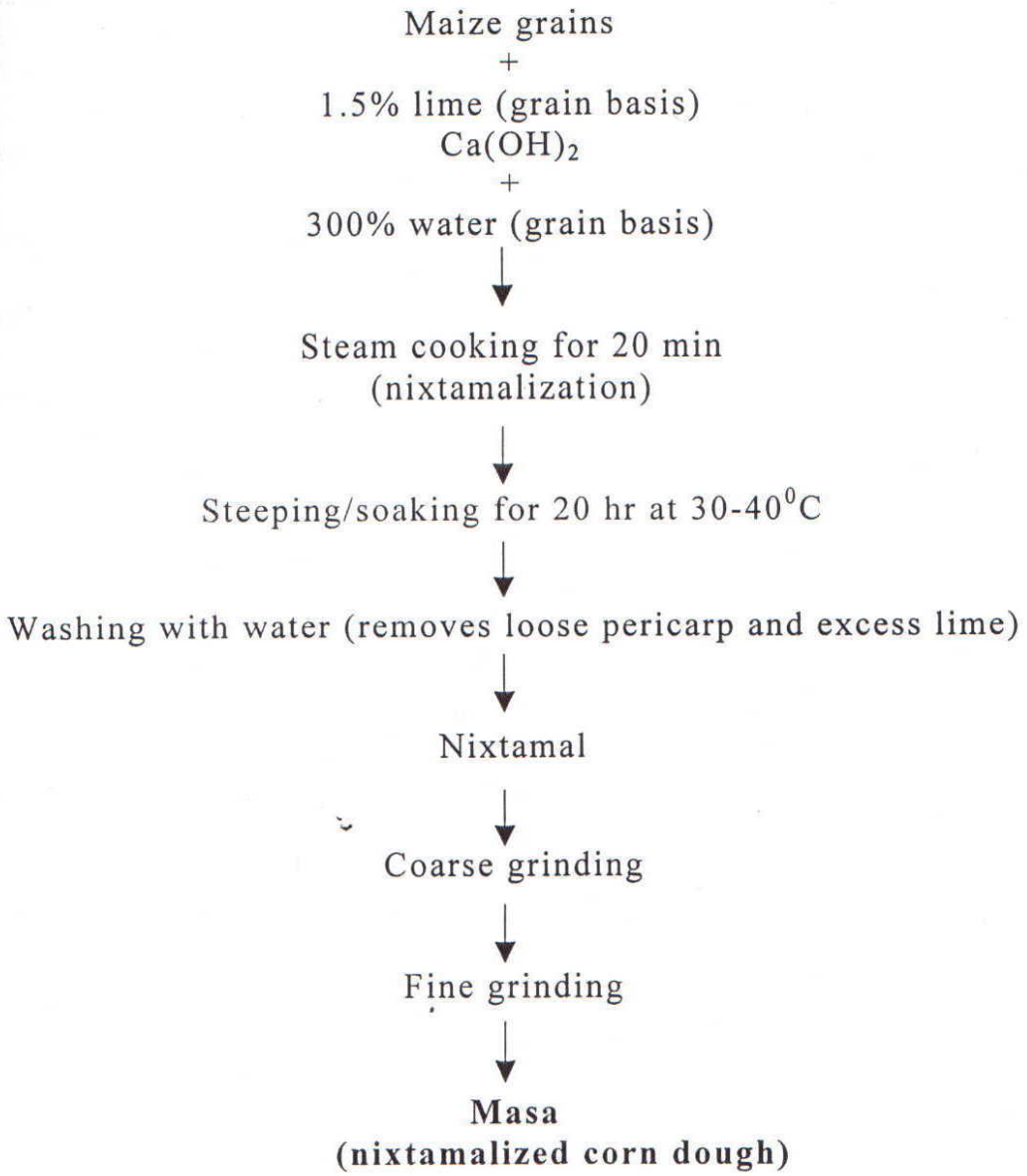


Fig. 1:PREPARATION OF MASA
(nixtamalized or alkali treated corn dough)

occasionally and steeped for 15 hrs (Khan *et al*, 1982). This method was very inconvenient as most of the water used for cooking evaporated during cooking. Second method of steam cooking (under pressure) was followed after standardizing the time of cooking, alkali concentration and amount of water used for cooking. The pericarp removal was easy and grains remained intact with lesser gruel solids loss during cooking. Nixtamalization treatment was done to soften the pericarp and endosperm, hydrate the protein matrix and gelatinize a small amount of starch (Rooney and Suhendro,1999). After nixtamalization, the grains were ground to get masa. The moisture content of masa was determined by the hot air oven method (AACC, 1990).

Table: 2: Moisture content of masa

	Variety			
	Sheetal	Parbhat	Partap-1	JH-4193
Moisture (%)	56.75	54.25	58	56

4.2.2 Dry masa flour (DMF)

Commercially, the nixtamal was ground using a modified, specially designed hammer mill. The ground particles were flash dried and sieved; coarse particles were ground and sieved and the particles were reformulated into correct particles size needed for

specific DMF. (Rooney and Suhendro, 1999). The method of production of dry masa flour is illustrated in Fig.2.

In the laboratory the nixtamal was first coarse ground in a mixer grinder and dried. After drying, the material was reground to particle size of 50-100 and >100μ. Instead of flash drying, the nixtamalized materials were dried in cabinet dryer and product prepared from dry masa flour was of very good quality.

4.3 Standardization of method of preparation of Tortilla and Corn chips.

4.3.1 Effect of different varieties

Data relating to the sensory parameters of tortilla and corn chips revealed that varieties did not affect the quality of tortilla chips.(Fig.3). But tortilla chips prepared from Sheetal variety had higher score for all sensory attributes followed by Parbhat. Similar pattern was observed for corn chips (Table 3). From appearance point of view, Sheetal and Parbhat had the highest scores (7.80) followed by JH-4193 (7.40). The color of products prepared from Sheetal was most acceptable (8.20) may be due to lighter color of this variety as compared to dark yellow of other three varieties. Basically, Indian maize is yellow to orange in color and is hard. So the products prepared from it had bright to dark yellow color and a relatively hard

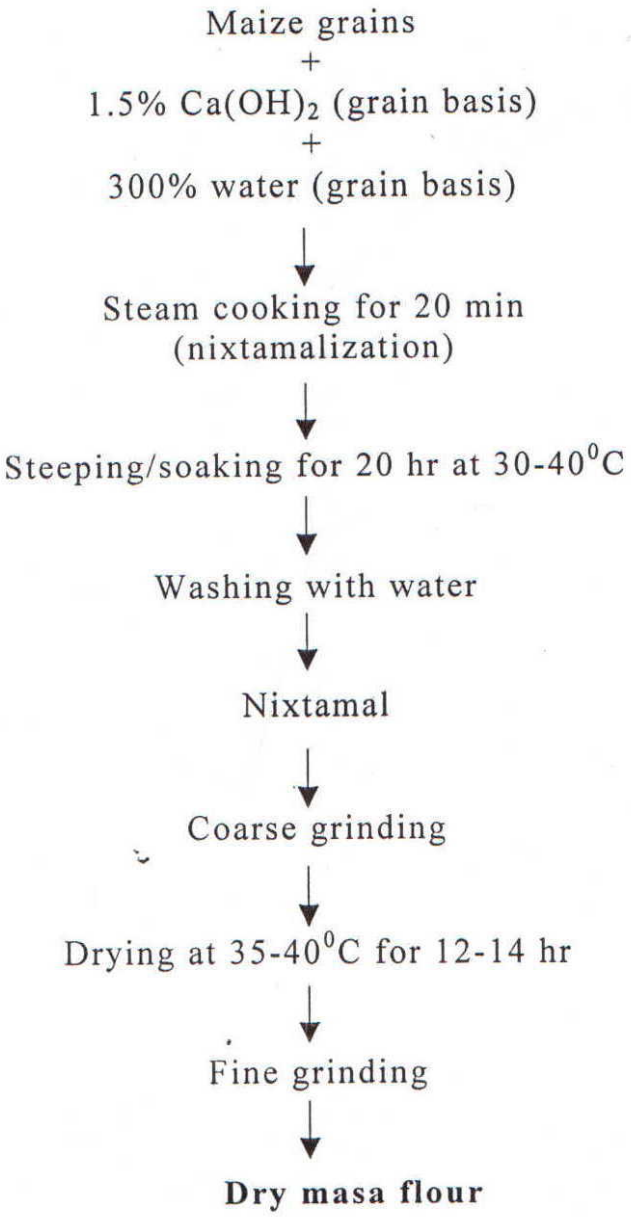


Fig: 2: PREPARATION OF DRY MASA FLOUR

Fig. 3a

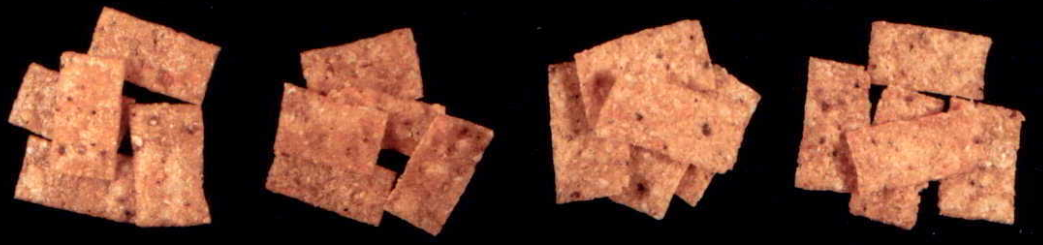
Fig. 3b

TORTILLA CHIPS



SHEETAL | PARBHAT | PARTAP-1 | JH-4193

CORN CHIPS



SHEETAL | PARBHAT | PARTAP-1 | JH-4193

Table 3 : The effect of varieties of maize on the sensory attributes

a) Tortilla Chips

Variety	Sensory Score (out of 9.0)				
	Appearance	Color	Texture	Taste	Overall acceptability
Sheetal	7.80[a]	8.20[a]	7.60[a]	7.60[a]	7.80[a]
Prabhat	7.80[a]	7.60[a]	7.00[a]	7.40[a]	7.45[a]
Partap-I	7.20[a]	7.20[a]	7.20[a]	7.20[a]	7.20[a]
JH-4193	7.40[a]	7.30[a]	6.20[a]	7.00[a]	6.98[a]

b) Corn Chips

Variety	Sensory Score (Out of 9.0)				
	Appearance	Color	Texture	Taste	Overall acceptability
Sheetal	8.20[b]	8.00[a]	7.60[a]	7.40[a]	7.80[a]
Prabhat	7.00[a]	7.00[a]	6.80[a]	6.80[a]	6.90[a]
Partap-I	7.00[a]	7.00[a]	6.80[a]	6.80[a]	6.90[a]
JH-4193	7.00[a]	7.00[a]	6.80[a]	6.80[a]	6.90[a]

The means having the same superscript do not differ significantly from each other ($p>0.05$)

texture. Tortilla and corn chips made from 100% yellow corn often had unacceptable, burnt flavor profiles. To overcome this problem corn hybrids with hard endosperm and white cob, easily removable pericarp and low dry matter losses were preferred (Gomez *et al* 1987). Sheetal had a lighter color as compared to other varieties and its pericarp removal was easy and it had no hard core after fine grinding on stone. Because pericarp removal was an important aspect for quality chips as it affected product color and texture (Serna-Saldivar *et al*, 1991), therefore, Sheetal variety, from which tortilla and corn chips were prepared and preferred followed by Parbhat.

4.3.2 Effect of particle size of dry masa flour (DMF)

The data depicting the effect of particle size (fine and coarse) of DMF on tortilla and corn chips quality is given in Table 4a and 4b respectively. Tortilla chips prepared from Parbhat had the highest scores for appearance of product (7.60) followed by Sheetal (7.40). But the overall acceptability was best for Sheetal (7.50). The fine particle size (50-100μ) of the DMF had better scores for all the sensory attributes as compared to the coarse DMF (>100μ). Although fried corn snacks required a moderately coarse masa, as it provides interruptions in the masa texture, permitting air and water vapor to escape during frying and thus preventing formation of bubbles or

Table 4a: The effect of particle size of dry masa flour on the sensory attributes of Tortilla Chips

Particle size	Variety	Sensory score (Out of 9.0) Appearance	Color	Texture	Taste	Overall Acceptability
Fine 50-100μ	Sheetal	7.40 [a]	7.60 [a]	7.40 [a]	7.60 [a]	7.50 [a]
	Parbhat	7.60 [a]	7.60 [a]	7.40 [a]	7.40 [a]	7.50 [a]
	Partap-I	6.40 [a]	6.20 [a]	6.80 [a]	6.40 [a]	6.45 [a]
	JH-4193	7.40 [a]	7.40 [a]	7.20 [a]	7.40 [a]	7.35 [a]
Coarse (>100 μ)	Sheetal	7.00 [a]	7.00 [a]	7.00 [a]	7.20 [a]	7.05 [a]
	Parbhat	7.20 [a]	7.60 [a]	7.00 [a]	7.60 [a]	7.35 [a]
	Partap-I	7.40 [a]	7.60 [a]	6.80 [a]	7.40 [a]	7.30 [a]
	JH-4193	7.20 [a]	7.40 [a]	6.80 [a]	7.80 [a]	7.30 [a]

The means having the same superscript do not differ significantly from each other ($p>0.05$).

Table 4b: The effect of particle size of dry masa flour on the sensory quality of Corn Chips

Particle size	Variety	Sensory score (Out of 9.0) Appearance	Color	Texture	Taste	Overall Acceptability
Fine 50-100μ	Sheetal	7.40 [a]	7.20 [a]	7.80 [a]	7.60 [a]	7.50 [a]
	Parbhat	7.60 [a]	8.00 [a]	7.60 [a]	8.00 [a]	7.80 [a]
	Partap-I	7.60 [a]	7.60 [a]	7.40 [a]	7.60 [a]	7.55 [a]
	JH-4193	7.80 [a]	7.80 [a]	7.40 [a]	7.60 [a]	7.65 [a]
Coarse >100μ	Sheetal	7.20 [a]	7.60 [a]	7.80 [a]	7.60 [a]	7.55 [a]
	Parbhat	7.40 [a]	7.60 [a]	7.20 [a]	7.60 [a]	7.45 [a]
	Partap-I	7.40 [a]	7.80 [a]	6.80 [a]	7.00 [a]	7.25 [a]
	JH-4193	7.40 [a]	7.60 [a]	7.20 [a]	7.60 [a]	7.45 [a]

The means having the same superscript do not differ significantly from each other ($p>0.05$).

pillows, breakage of chips and high oil uptake (Gomez *et al*, 1987). Highly coarse particle size should not be preferred because the particles do not disintegrate or bind properly and are dominantly visible in the final product. This was the reason for the low acceptability of the tortilla chips from coarse DMF. Similar was the case with corn chips prepared from fine and coarse particle size. Corn chips prepared from dry masa flour were best in appearance, color and taste from Prabhat followed by Sheetal. Inspite of this, it was very evident from the tables that the overall acceptability of Sheetal was highest (7.50) with equal rating of Prabhat and JH – 4193. Partap I was the most unsuitable variety to prepare DMF as it had lowest scores for almost all the sensory attributes for tortilla and corn chips.

4.3.3 Effect of sheeting thickness

Table 5 depicts the different thickness of sheet for tortilla and corn chips. Not much variation was observed with respect to the sensory score of chips. However, overall chips prepared from sheeting thickness 0.05cm had better score for appearance and overall acceptability than 0.2cm thick as inferred from values i.e. 8.20 and 6.20 respectively. From the sensory score of tortilla chips and corn chips of sheeting thickness 0.05, 0.1 and 0.2cm; the thin sheeting 0.05 was considered best for tortilla and corn chips on the

Table 5: The effect of sheeting thickness on the sensory attributes

a) Tortilla Chips

Sheeting Thickness (cm)	Sensory Score (Out of 9.0)				
	Appearance	Color	Texture	Taste	Overall Acceptability
Thin (0.05)	8.20[c]	7.60[a]	8.00[a]	8.00[a]	7.95[a]
Medium (0.1)	7.40[b]	7.60[a]	8.20[a]	8.20[a]	7.85[a]
Thick (0.2)	6.20[a]	7.20[a]	7.00[a]	7.60[a]	7.00[a]

b) Corn Chips

Sheeting Thickness (cm)	Sensory Score (Out of 9.0)				
	Appearance	Color	Texture	Taste	Overall Acceptability
Thin (0.05)	8.00[a]	8.00[a]	8.00[c]	8.00[a]	8.00[a]
Medium (0.1)	8.00[a]	7.60[a]	7.00[b]	6.80[a]	7.35[a]
Thick (0.2)	6.60[a]	7.40[a]	5.60[a]	6.40[a]	6.50[a]

The means having the same superscript do not differ significantly from each other ($p>0.05$).

basis of appearance, color texture, taste and overall acceptability. The thickness of chips should vary between 1-5mm or 0.04-0.20 inch (Waniska, 1999) or it may be 0.10 inch for standard restaurant "table" tortilla chips and 0.03 inch for snack chips (Deis, 2000). So taking into account the overall acceptability, 0.05 cm thick sheeting is recommended as thicker chips become soggy after frying and absorbed more oil.

4.3.4 Effect of baking temperature and time

Table 6 represents the effect of baking temperature and time (200, 240, 280^{0}C for 1, 2, 3, 4 min.) for tortilla chips. Within the temperature of 200^{0}C, there was no significant difference between the various time parameters for all the quality aspects. Using temperature of 240^{0}C, the appearance of the chips baked for 1 and 2 minutes was best (8.20 both), but the color of 2 min. baked chips was better (8.60) followed by 1 min. baked chips. Similar was the case of scoring for overall acceptability, which depicted that 2 min. baked chips were best (8.05). Baking time of 4 min. at 240^{0}C tend to make the chips dry, thus deteriorating the texture on frying. In 280^{0}C range baking time of 3 and 4 min. were highly unacceptable in terms of all the quality aspects because chips got burnt at such a high temperature and had dark brown color. Taste was also unacceptable. So the overall acceptability decreased with increasing temperature

Table 6: The effect of baking temperature and time on the sensory quality of Tortilla Chips.

Temp. (^{0}C)	Time (min)	Sensory score (Out of 9.0) Appearance	Color	Texture	Taste	Overall Acceptability
200	1	7.40 ^{a}	7.80 ^{a}	7.40 ^{a}	8.00 ^{a}	7.65 ^{a}
	2	7.60 ^{a}	7.80 ^{a}	7.80 ^{a}	7.80 ^{a}	7.75 ^{a}
	3	7.60 ^{a}	7.80 ^{a}	7.60 ^{a}	7.80 ^{a}	7.70 ^{a}
	4	7.40 ^{a}	7.60 ^{a}	7.40 ^{a}	7.80 ^{a}	7.55 ^{a}
240	1	8.20^c	8.40 ^{a}	7.80 ^{a}	7.80 ^{a}	8.05 ^{a}
	2	8.20^c	8.60 ^{a}	7.80 ^{a}	7.60 ^{a}	8.05 ^{a}
	3	7.80^b	8.20 ^{a}	7.20 ^{a}	7.60 ^{a}	7.70 ^{a}
	4	7.00 ^{a}	7.60 ^{b}	7.20 ^{a}	7.80 ^{a}	7.40 ^{a}
280	1	7.80^c	8.20^d	7.40 ^{a}	7.00 ^{a}	7.60^c
	2	8.00^d	8.00^c	7.40 ^{a}	7.20 ^{a}	7.65^d
	3	5.80^b	5.60^b	7.40 ^{a}	6.40 ^{a}	6.30^b
	4	5.40^a	5.20 ^{a}	7.20 ^{a}	5.60 ^{a}	5.85 ^{a}

The means having the same superscript do not differ significantly from each other ($p>0.05$).

and time of baking. At high temperature complete baking occurred. But, the tortilla chips should not to be baked completely and allowed to equilibrate for sometime (Gomez *et al*, 1987). Also tortillas baked for longer time yielded browned and large puffed areas (Waniska, 1999). Among the three temperatures and time ranges, the combination that gave best score in terms of appearance, color, texture, taste and overall acceptability was 240^{0}C for 2 min.

4.3.5 Effect of frying temperature and time

The data illustrating the frying temperature and time for chips showed that there were no significant differences between the time ranges in a particular temperature as shown in Table 7a and 7b. Tortilla chips fried for 1 and 2 min. at 180^{0}C were a bit soggy and had low scores for overall acceptability (7.15, 7.40 respectively). The time of 3 min. at this temperature gave good results for appearance, color, texture (7.60 each) and overall acceptability (7.55). Tortilla chips exposed to higher temperature (190^{0}C) in a non aqueous medium during frying resulted in a low moisture content of tortilla chips after frying (Gomez *et al*, 1992). So in temperature range of 190^{0}C, the appearance and color of 1 minute fried chips was best (7.60). But the texture, taste (7.60 both) and overall acceptability (7.50) of 1.5 minute fried chips were rated highest (7.60 for all). At temperatures of 200^{0}C and above, the sensory score

Table 7a: The effect of frying temperature and time on the sensory attributes of Tortilla Chips.

Temp. (^{0}C)	Time (min)	Sensory score (Out of 9.0)				
		Appearance	Color	Texture	Taste	Overall Acceptability
180	1	7.60 [a]	7.60 [a]	6.80 [a]	6.60 [a]	7.15 [a]
	2	7.60 [a]	7.60 [a]	7.40 [a]	7.00 [a]	7.40 [a]
	3	7.60 [a]	7.60 [a]	7.60 [a]	7.40 [a]	7.55 [a]
190	1	7.60 [a]	7.60 [a]	7.40 [a]	7.20 [a]	7.45 [a]
	1.5	7.40 [a]	7.40 [a]	7.60 [a]	7.60 [a]	7.50 [a]
	2	7.40 [a]	7.40 [a]	7.40 [a]	7.60 [a]	7.45 [a]
200	0.5	7.40 [b]	7.20 [a]	7.20 [a]	6.40 [a]	7.05 [c]
	1	6.20 [a]	6.20 [a]	7.20 [a]	5.40 [a]	6.25 [b]
	1.5	6.20 [a]	6.20 [a]	6.80 [a]	5.20 [a]	6.10 [a]
210	0.5	7.40 [c]	7.20 [c]	7.40 [a]	6.40 [a]	7.10 [c]
	1	5.40 [b]	5.40 [b]	6.40 [a]	5.20 [a]	5.60 [b]
	1.5	4.60 [a]	4.60 [a]	6.20 [a]	4.60 [a]	5.00 [a]

The means having the same superscript do not differ significantly from each other ($p>0.05$).

for all the parameters decreased significantly because due to baking of tortilla chips, the moisture content was already low and after frying chips got burnt and overall acceptability decreased. In case of corn chips, higher temperatures were required for frying to volatilize the extra water in the masa (Gomez *et al*, 1987). As evident from Table 7b, the overall acceptability and other parameters for temperature 180^{0}C did not vary significantly. Using of temperature of 190^{0}C, frying time of 1 min. had good scores for color and texture (8.00). But frying time of 1.5 min. had best scores for all the sensory attributes and its overall acceptability was the best (7.95). At higher temperatures, the same results were obtained as in case of tortilla chips i.e. the product gave burnt flavor and color.

4.3.6 Effect of different shapes

The data related to the effect of different shapes on the acceptability of the product is given in Table 8a and illustrated in Fig 4. The different shapes of tortilla chips did not differ significantly in sensory quality as observed from the sensory scores. From appearance point of view, circular shape was most appealing to the judges as it scored the highest (8.60) among shapes. The usual shape of tortilla chips is mostly round deli- style and triangular shaped restaurant style (Deis, 2000). Triangular chips had better acceptability than square and big rectangular shape. In terms of the

Table 7b: The effect of frying temperature and time on the sensory attributes of Corn Chips.

Temp. (^{0}C)	Time (min)	Sensory score (Out of 9.0) Appearance	Color	Texture	Taste	Overall Acceptability
180	1	7.60 [a]	7.60 [a]	7.60 [a]	7.40 [a]	7.55 [a]
	2	7.60 [a]	7.80 [a]	7.80 [a]	7.60 [a]	7.70 [a]
	3	7.60 [a]	7.80 [a]	7.80 [a]	7.40 [a]	7.65 [a]
190	1	7.80 [a]	8.00[b]	8.00 [a]	7.80 [a]	7.90[b]
	1.5	8.00 [a]	8.00[b]	8.00 [a]	7.80 [a]	7.95[b]
	2	7.40 [a]	7.40 [a]	7.63 [a]	7.40 [a]	7.45 [a]
200	0.5	6.60 [a]	6.80 [a]	4.20 [a]	4.60 [a]	5.55[a]
	1	6.60 [a]	6.60 [a]	6.20 [a]	5.80 [a]	6.30 [a]
	1.5	6.60 [a]	6.80 [a]	6.20 [a]	5.60 [a]	6.30 [a]
210	0.5	7.00 [a]	7.00 [a]	5.40[a]	5.40 [a]	6.20 [b]
	1	6.80 [a]	6.80 [a]	6.80[b]	6.00 [a]	6.60 [c]
	1.5	6.60 [a]	6.60 [a]	6.80[b]	5.80 [a]	6.45 [a]

The means having the same superscript do not differ significantly from each other ($p>0.05$).

overall acceptability, the regular small rectangular shaped tortilla chips scored highest (7.85). The overall acceptability score of tortilla chips for all shapes ranged from 7.50 to 7.85 which showed that all shapes were preferred depending on the individual preference.

4.3.7 Effect of different seasonings

Different types of seasonings were used in study, viz., salt @ 2%, cumin @ 1%, celery @ 1% and mixed seasonings (salt @ 1%, coriander powder @ 0.5%, black pepper powder @ 0.5%, cumin powder @ 0.5%)(Table 8b and Fig 5). The data revealed that sensory quality of the chips with different seasonings did not differ significantly. The chips sprinkled with mixed seasonings rated the best (8.22) followed by addition of cumin (7.90) and celery (8.00). The higher acceptability may be attributed to the better taste, flavor and appearance of these chips. Sensory quality varies according to taste. So wide variety of seasonings can be used for the different taste groups of consumers. Special ingredients may also be used to improve texture and add flavorants to baked chips. Sometimes maize flavor is also sprinkled on chips (Rooney and Suhendro, 1999). Numerous flavors can be added to the chips e.g. Cheesy nacho, salsa and black bean, lime flavored varieties, onion and garlic, honey, mustard, chili and lime, cinnamon, garlic and vinegar, fresh tomato etc (Deis, 2000). It is evident from the data that chips sprinkled with

Table 8: The sensory attributes of Tortilla Chips

a) Different shapes

Shape	Sensory score (Out of 9.0)				
	Appearance	Color	Texture	Taste	Overall Acceptability
Small rectangular	7.80 [a]	8.00 [a]	7.80 [a]	7.80 [a]	7.85 [a]
Big rectangular	7.20 [a]	7.80 [a]	7.60 [a]	7.40 [a]	7.50 [a]
Square	7.60 [a]	8.00 [a]	7.60 [a]	7.80 [a]	7.75 [a]
Triangular	7.80 [a]	8.00 [a]	7.60 [a]	7.60 [a]	7.75 [a]
Circular	8.60 [a]	8.00 [a]	7.40 [a]	7.40 [a]	7.85 [a]

b) Different seasonings

Seasonings	Sensory score (Out of 9.0)				
	Appearance	Color	Texture	Taste	Overall Acceptability
Plain Salty	8.30 [a]	8.30 [a]	8.00 [a]	7.70 [a]	8.07 [a]
Cumin	7.60 [a]	7.80 [a]	8.00 [a]	8.20 [a]	7.90 [a]
Celery	7.80 [a]	7.70 [a]	8.20 [a]	8.30 [a]	8.00 [a]
Salt sprinkled	7.80 [a]	8.00 [a]	8.30 [a]	7.60 [a]	7.92 [a]
Mixed seasonings sprinkled	8.00 [a]	8.10 [a]	8.20 [a]	8.60 [a]	8.22 [a]

The means having the same superscript do not differ significantly from each other ($p>0.05$).

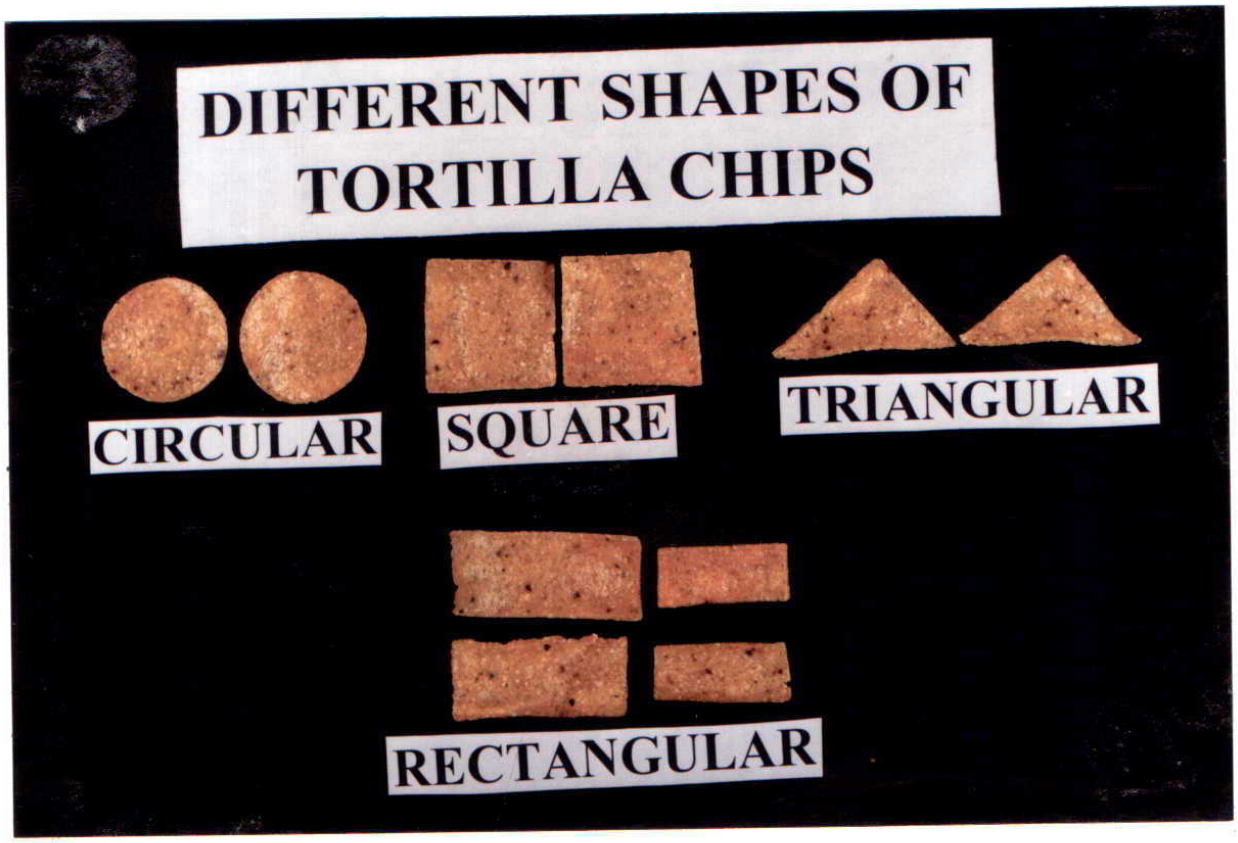
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Fig. 4

Fig. 5

1: Plain
2: Cumin
3: Celery
4: Salt Sprinkled
5: Mixed Seasonings Sprinkled


DIFFERENT SHAPES OF TORTILLA CHIPS
CIRCULAR
SQUARE
TRIANGULAR
RECTANGULAR


SEASONING OF CHIPS
1
2
3
4
5

mixed seasonings were most acceptable. Therefore, it is recommended with variations in the ingredients used.

4.4 Storage quality

Data depicting the effect of packaging material and storage time on the quality of tortilla and corn chips is given in Table 9a and 9b. The chips were packed in aluminum foil laminated and polyethylene packs. After 1 week the appearance, color and texture of tortilla chips were not affected and overall acceptability of chips packed in both the packaging materials was also good (Table 9a). Upto 3 weeks of storage at average temperature of 28-35^{0}C, the overall acceptability of chips packed in both types of packaging material was similar (7.80 and 7.75). There was not much variation in the sensory attributes of the tortilla chips even up to 5 weeks of storage with average temperature of 28-35^{0}C. There was little change in taste of tortilla chips packed in polyethylene packs. After 7 weeks of storage, there was no significant decrease in quality in terms of appearance and color but in the overall acceptability score (6.65 and 6.80) of tortilla chips packed in both types of packaging material got affected. After 11 weeks of storage, the overall acceptability of chips packed in aluminium foil laminated pack (5.40) deteriorated. This

Table 9a: The effect of storage time on the sensory attributes of Tortilla Chips

Storage time (Weeks)	Aluminium foil laminated pack					Polyethylene pack				
	Appearance	Color	Texture	Taste	Overall acceptability	Appearance	Color	Texture	Taste	Overall acceptability
1	8.20 [a]	8.20 [a]	8.20[d]	8.00[e]	8.15[f]	8.40 [a]	8.20[a]	8.10[e]	8.20[e]	8.22[f]
3	8.00 [a]	7.80 [a]	7.60[c]	7.80[d]	7.80[e]	7.80 [a]	7.80 [a]	7.60[d]	7.80[d]	7.75[e]
5	7.40 [a]	7.40 [a]	7.20[b]	7.00[c]	7.25[d]	7.60 [a]	7.60 [a]	7.00[c]	6.80[c]	7.25[d]
7	7.20 [a]	7.20 [a]	6.40 [a]	5.80[b]	6.65[b]	7.20 [a]	7.60 [a]	6.60[b]	5.80[b]	6.80 [b]
9	7.00 [a]	7.20 [a]	6.40 [a]	5.40 [a]	6.50[c]	7.20 [a]	7.50 [a]	6.50 [a]	5.70 [a]	6.72[c]
11	7.00[a]	7.20[a]	6.20[a]	5.40[a]	6.45[a]	7.20[a]	7.20[a]	6.50[a]	5.70[a]	6.65[a]

The means having the same superscript do not differ significantly from each other ($p>0.05$).

may be attributed to the change in taste and texture of chips. But there was no significant change in chips packed in polyethylene (6.65).

Corn chips stored in polyethylene packs were better than those packed in aluminum foil laminated packs in terms of appearance, color, texture, taste (8.40) and overall acceptability (8.40). Although the chips packed in aluminum foil laminated packs also had good acceptability (8.05) after 1 week, but the acceptability of polyethylene packed chips was better. This may be due to the reason that polyethylene has high gas transmission rate. So rancid flavor escapes from the pack. After 3 weeks with average temperature of 28-35^{0}C, the overall acceptability of chips packed in both types of packaging material did not change significantly. Same case was observed after 5 weeks (average temperature 28-35^{0}C) with little decrease in taste of both types of chips. After 7 weeks of storage the appearance and color of the product did not changed much, but there was a slight change in textural and taste properties of the product for both types of packed chips. Overall the product remained acceptable as inferred from overall acceptability score of the chips packed in aluminum foil laminated packs (6.85) and polyethylene packs (6.85). According to Almeida-Dominguez *et al* (1992), if the frying oil was added with 0.01% tertiary butylated hydroxyquinone (TBHQ)

Table 9b: Mean values of the effect of storage time on the sensory quality of Corn Chips

Storage time (Weeks)	Aluminium foil laminated pack					Polyethylene pack				
	Appearance	Color	Texture	Taste	Overall acceptability	Appearance	Color	Texture	Taste	Overall acceptability
1	7.80 ^{a}	8.20^{e}	8.00^{e}	8.20^{f}	8.05^{f}	8.40^{e}	8.40^{f}	8.40^{f}	8.40^{d}	8.40^{f}
3	8.00 ^{a}	8.00^{d}	7.80^{d}	8.00^{e}	7.95^{e}	7.80^{c}	7.80^{d}	7.60^{e}	7.60^{c}	7.70^{e}
5	7.80 ^{a}	7.80^{c}	7.20^{c}	6.80^{d}	7.40^{d}	8.00^{d}	8.00^{e}	7.40^{d}	6.60^{b}	7.50^{d}
7	7.20 ^{a}	7.60^{b}	6.40^{b}	6.20^{c}	6.85^{c}	7.20^{b}	7.40^{c}	6.80^{c}	6.00 ^{a}	6.85^{c}
9	7.00 ^{a}	7.00^{a}	6.40^{b}	5.60 ^{b}	6.50 ^{b}	7.00^{a}	7.00^{b}	6.50^{b}	6.00 ^{a}	6.62 ^{b}
11	7.00^{a}	7.00^{a}	5.80^{a}	5.20^{a}	6.25^{a}	7.00^{a}	6.60^{a}	6.00^{a}	6.00^{a}	6.40^{a}

The means having the same superscript do not differ significantly from each other($p>0.05$)

antioxidant and chips were packed in high-density polyethylene (HDPE) bags, it resulted in higher shelf life. After 11 weeks of storage, the corn chips had lower acceptability scores (6.25 and 6.40) but they were in acceptable range. With increase in storage time and temperature, the acceptability of product was not affected.

4.5 Process Standardization

4.5.1 Tortilla Chips

The method of production of tortilla chips is given in Fig 6. The nixtamal was coarsely ground in mixer grinder and then finely ground on stone to obtain masa. The moisture content of masa was between 54 – 58%. Salt was mixed in it @ 2%. Masa was then sheeted with the help of rolling pin and board to a thickness of 0.05 cm. The sheeted masa was then cut into small rectangular pieces of about 4 x 1.5 cm size. These were then baked in the oven at a temperature of 220^{0}C for 2 minutes. The moisture content of chips after baking was approximately 27.5%. The baked chips were given a period of 10-15 minutes for conditioning so that all the moisture in it gets equilibrated. These were then deep fried in automatic deep fat fryers at a temperature of 190^{0}C for 1.5 min. The fried chips were

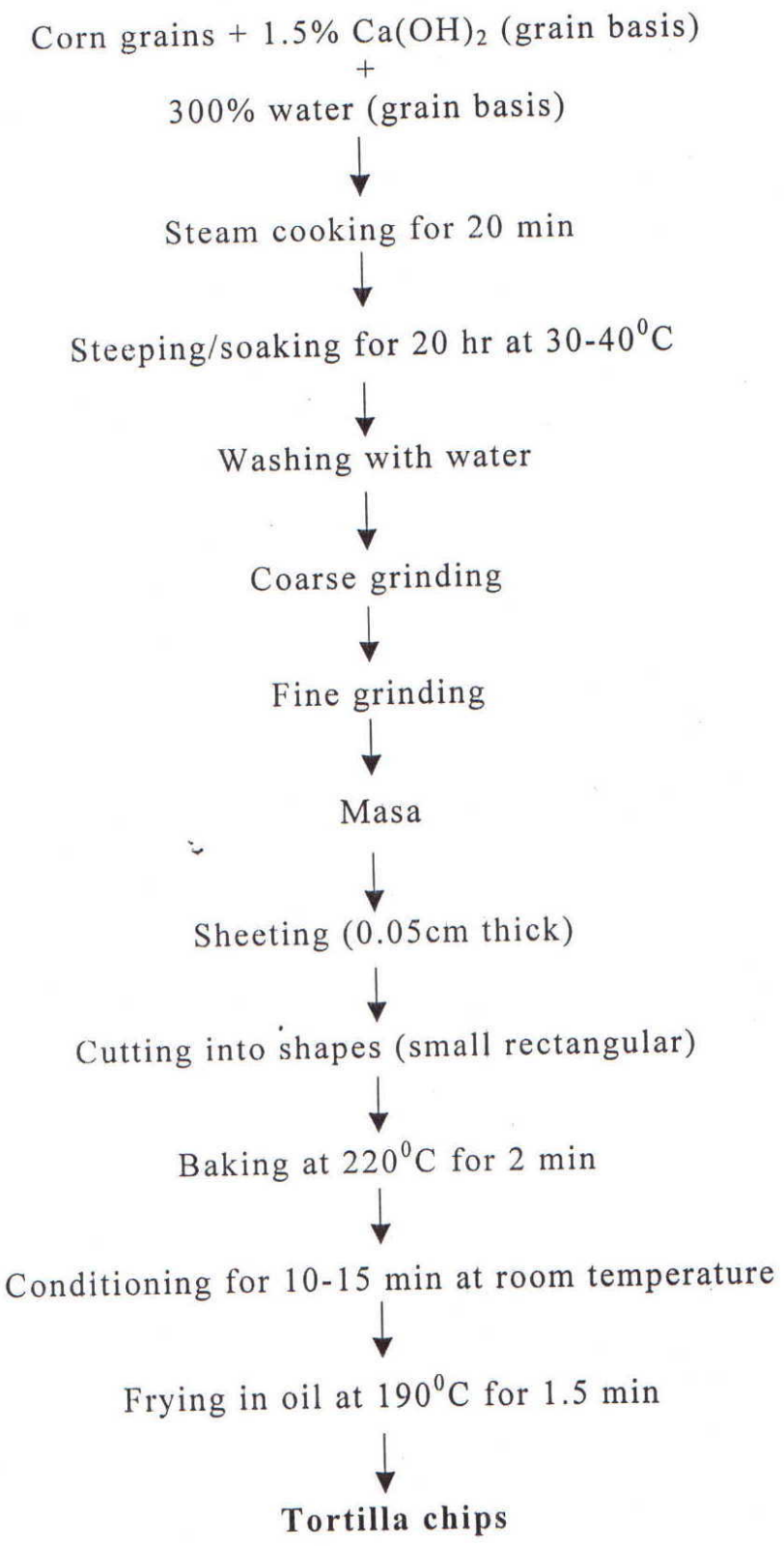


Fig 6: PREPARATION OF TORTILLA CHIPS

cooled and then packed. Seasonings may be mixed before sheeting or sprinkled after cooling.

4.5.2 Corn Chips

The method of production of corn chips is given in Fig 7. The nixtamal was coarsely ground and finely ground as in case of tortilla chips. Salt was added @ 2% in masa which was then sheeted and cut into small rectangular shapes of size 4 x 1.5cm. These chips were then deep fried in oil at a temperature of 190^0C for 1.5 minutes. The chips were cooled and packed.

4.6 Proximate composition of Tortilla and Corn Chips

Table 10 represented the proximate composition of tortilla and corn chips. The crude protein and fat in tortilla and corn chips were found to be 11.60, 15.05 per cent and 12.12, 21.40 per cent respectively. In tortilla chips, due to baking, the oil absorption was less. The moisture content of chips after baking was approximately 27.5%. In case of corn chips, the moisture content before frying was high (55-60%) so it absorbed more oil. Gomez *et al* (1987) reported that the moisture content of tortilla chips after baking, after frying and oil content after frying was 40%, 1-1.2% and 25% respectively. For corn chips the moisture content after sheeting, after frying and

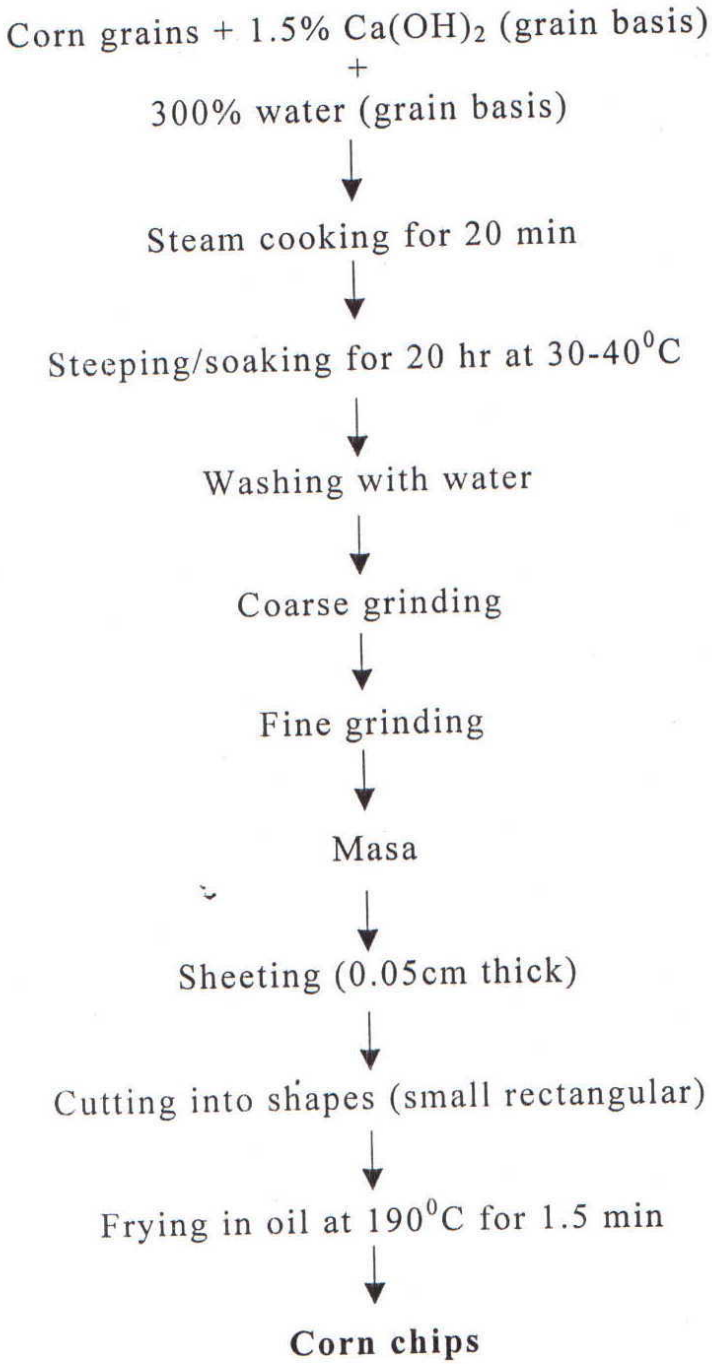


Fig 7: PREPARATION OF CORN CHIPS

oil content after frying was 50-52%, 1-1.5% and 35% respectively. The proximate composition of tortilla and corn chips given by Almeida-Dominguez *et al* (1998) was % crude protein, starch, ash as 9.7, 70-75, 1.6-1.9 respectively. In comparison to these values, our product had lesser fat may be due to the variations in the raw material used.

Table 10: Proximate composition of Tortilla and Corn Chips.

	Tortilla Chips	Corn Chips
Crude Protein (%, N x 6.25)	11.60	12.12
Crude Fat (%)	15.05	21.40
Ash (%)	0.27	0.19
Starch (%)	54.49	50.69
Total Sugars (%, Glucose)	4.14	2.30
Reducing Sugars (% Glucose)	3.37	2.09
Non reducing Sugars (%, Glucose)	0.71	0.21

Chapter- V

Summary and Conclusions

The present investigations were carried out to study the potential use of Indian maize varieties using different variables and standardize the processing conditions for development of tortilla and corn chips. These were assessed for their organoleptic properties. Four varieties of maize were used; viz. Sheetal, Parbhat, Partap I, JH – 4193. Tortilla and corn chips were prepared from these varieties and the best variety was chosen on the basis of physical parameters, product quality and proximate composition. This variety was further used in the study with different variables to obtain the best recipe and process for tortilla and corn chips. Details regarding the method of production and experimental procedures are given in Chapter III under Material and Methods. Results obtained are summarized below:

The maize varieties had a protein content in the range of 11.74 – 12.65%. Variety Sheetal, which was used for the variables, had a moderate protein and starch content whereas it had the lowest ash, fat and sugar content. Variety Partap I had lowest protein and starch, whereas JH–4193 had highest percentage for these components. Variety Parbhat had moderate amounts of all the components.

The best-suited variety Sheetal was further used in nixtamalization. For the standardization of process nixtamalization, different variations were used for cooking time of grains, alkali concentration and amount of water used for cooking (as described in Chapter III). After various trials, the standard method was chosen with 1.5% alkali, 300% water (both on grain basis) and 20 minutes of steam cooking. Steeping was done for 20 hours. This method was standardized on the basis of easy pericarp removal and lesser gruel solid loss.

The method of production of dry masa flour was also standardized. Dry masa flour was very convenient to use and was prepared by drying the coarse ground masa at a temperature of about 35-40^{0}C for 12-14 hours and then reground to a desirable particle size (50-100μ and > 100μ).

Tortilla chips and corn chips were made from the four varieties. Although there was no significant difference between the varieties, but in terms of overall acceptability, Sheetal was best on basis of sensory scores of all the attributes of both tortilla and corn chips followed by Parbhat. JH – 4193 was the most unsuitable variety for both tortilla and corn chips in terms of texture, taste and overall acceptability of final product. Therefore, Sheetal variety was chosen

to produce tortilla and corn chips with further variations in the recipe.

Dry masa flour was prepared from all the four varieties of two particle sizes (fine and coarse). There was no variation in the four varieties with respect to product quality using DMF. Tortilla chips and corn chips prepared from finer particle size had more acceptability than coarser one as it had better appearance and texture of product.

The nixtamalized grains were ground to obtain masa, which was sheeted using different thickness of tortilla and corn chips. The thickness of 0.05cm was most preferred in terms of appearance, texture and overall acceptability. 0.2cm thick chips were soggy and puffy, so they had the least score of texture, taste and overall acceptability. The thickness of 0.1cm (medium) had a moderate acceptability. But corn chips of even this much thickness were little soggy. So the preferred and recommended thickness of chips should be 0.05cm.

The scores for appearance, color, texture and overall acceptability was best for tortilla chips baked at 240^0C for 2 minutes in comparison to higher temperature. At higher temperature, the chips ends got burnt and overall acceptability decreased

significantly. At lower temperature, there was no significant decrease in appearance of the chips. But the preferred temperature was 240^0C.

For standardization of frying temperature and time of tortilla and corn chips, these were subjected to 180, 190, 200 and 210^0C temperatures for different times. The highest score for all the sensory parameters for tortilla and corn chips were obtained using a frying temperature of 190^0C for 1.5 minute. At a higher temperature, the chips had burnt flavor and dark color, so the overall acceptability decreased. At a lower temperature, the chips were under fried or soggy in taste and texture.

Tortilla chips of different shapes were prepared. Overall acceptability of small rectangular shaped chips was highest. The circular chips rated best in terms of appearance. Triangular chips also had good acceptability score. Small rectangular chips were recommended having higher acceptability.

Seasoning of chips had wide acceptability and variability due to different taste preferences of the panelists. The chips with mixed seasonings sprinkled ranked the highest in terms of overall acceptability. The ingredients of this mixed seasoning can vary according to taste. The cumin and celery flavored chips also had good overall acceptability. In terms of appearance and color, the plain salty chips had highest score.

Tortilla chips and corn chips had very good acceptability after 7 weeks of storage in aluminum foil laminated and polyethylene pack. After 11 weeks, the taste and acceptability in both types of packs was affected due to slight rancid flavor development at higher temperature of storage. The corn chips packed in aluminum foil laminated pack deteriorated a little in taste due to development of rancid flavor in the 7^{th} week. Overall, the chips were in acceptable range in both types of packaging material for 11 weeks of storage time.

The process of production of tortilla and corn chips was standardized using the best combination of all the variables. The method is given in Chapter IV (4.5). The only difference between the two products was the additional step of baking in tortilla chips, which leads to the difference in final product characteristics. Corn chips being higher in oil content give oily taste whereas tortilla chips give a little bit dry feel as compared to corn chips.

The protein content of tortilla and corn chips was 11.60 and 12.12 per cent respectively. Tortilla chips had a lesser fat content (15.05 per cent) due to baking which reduces moisture and helped in less fat absorption. The corn chips had a fat content of 21.40 per cent. The % ash, starch and total sugars in tortilla and corn chips were in the normal range.

CONCLUSIONS

Based on the results, the best recommended formula for the preparation of good quality tortilla and corn chips is as follows:

Maize grains	100g
Ca(OH)2	1.5g
Water	300ml
Salt	2g
Frying oil	As per required
Optional ingredients	
Cumin	1g
Celery	1g
Coriander powder	0.5g
Black pepper powder	0.5g

Standardized method of preparation is as follows:

Preparation of masa:

Maize grains	100g
Alkali	1.5g
Water	300ml
Steam cooking	20 minutes
Steeping	20 hours at 30-40^{0}C

Washing	To remove pericarp and residual line
Coarse grinding	In mixer grinder
Fine grinding	On stone to get masa
Sheeting	0.05cm thick
Cutting	Small rectangular shape of 4 x 1.5 cm
*Baking temperature	220^0C
*Baking time	2 minutes
Frying temperature	190^0C
Frying time	1.5 minutes
Packaging material	Aluminum foil laminated polyethylene packs(100 gauge).

* Only for tortilla chips.

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