Quality improvement of breading

By

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DECLARATION

The work is described in this thesis was carried out by me at the keels food product limited under the supervision of Mr. Saman Jayaratne and Dr.K.K.D.S.Ranaweera. A report on this has not been submitted to any other University for another degree.

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AFFECTIONATELY DEDICATED

TO MY EVERLOVING

PARENTS, BROTHERS AND SISTER

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Abstract

Breading is generally used as an outer coating of crest range meat products It imparts crispy oily and slippery mouth feel to crest range meat products A study carried out was intended to further improve the quality of breading In the study quality characters such as colour crispness hard to bite and oiliness were taken as main properties to consider In addition reduction of overall oil absorption of the product by using the improved coating was also attempted

Improvement of breading formulae was mainly done by replacing some ingredients with several new counterparts and changing the composition of the breading

The breading samples improved were comparatively evaluated with market sample for its sensory properties Several laboratory tests were carried out to check efficcasy of some ingredients as well

The results obtained from the sensory evaluation were very satisfactory and revealed that the improved sample proved to have better qualities especially for crispness hardness and colour

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Chapter 1
Introduction

The breading is a flour based ground coating, used by the food industry for as long as the foods have been fried It is further defined in several ways as, flour based bread crumb or cracker meal that is applied to a food in a dry form primarily to create a desired coating texture, as a dry food coating made from flour, starch, seasoning etc, that is coarse in nature and is applied over moistened or battered food products, (suderman and Cunningham (1983)), the coating can be fine to coarse in particle size. (David 1998) However the use of breadings to manufacture prefried convenience foods began only in the middle 1950s

In Sri Lanka the consumption of frozen foods is becoming popular and the demand of the breading go higher These products are normally called crest range products The breadings are used as outercoat of these crest range meat products such as chicken drumsticks fishfingers etc At present, breading produced in Sri Lanka hardly reaches the standards and does not meet the requirements of the target customer group for its some characters Undesirable characters such as excess dark brown colour less crispness, harden interior, less slippery mouth feel and more oil retention properties in the local produced breadings makes major problems to sri lankan meat industry

Since the main theme of the today's market is customer satisfaction the producer is more concerned with quality products Likewise the meat producers in Sri Lanka have to go for international market for required quality breading On the other hand Sri Lankan meat producer face many drawbacks such as

- Increased cost
- Transportation delays
- Susceptible to defectives such as termite and fungal attack

Continuous quality improvement of breadings may help the local producers to reach the international standards of meat products However it is seldom carried out The quality improvement in long run seems to be profitable for both producer and customer safetywise and qualitywise

In order to address the above problems **objectives** of the present study were set as follows

1 Quality improvement in breadings

2 Reduction of overall oil absorption in the whole meat products

3 Comparison of the quality of the improved samples with samples available at the local market

Chapter 2

Literature survey

2.1 Breading

These are large group of flour based ground coatings using for fried products. There are several methods used in the preparation of breading;

1 Cracker meal
2 Home style
3 Japanese
4 Extruded

2.2 Breading characteristics

Finished product characteristics of breading are more concerned together with their functionality

2.2.1 Colour and appearance

Coarser fractions do provide initial, visual interest more than the fine crumbs. The selection of browning rate and particle size must take in to account the fry time required to ensure that the food is fully cooked from a frozen state.
E g some products need more time for frying than others fry They need less browning rate breading

The fried colour of a breaded product is proportional to the amount of reducing sugar in it A coating of uniform colouration is obtained by the blending of coarse and fine particles having specified rates of browning, since too coarse low tolerance crumbs may give unacceptably dark highlights, whereas a finer mesh more tolerant crumb will run safely with even colour Final coating colour of the meat products can be further affected by natural and artificial colouring agents added during breading manufacture

2.2.2 Crispness

When the particle size of breading is increased more crispness is achieved The crispier breading come from coarse particles which holds through sieve size U S mesh 6 The crispness decreases gradually then it means the more the coarser more the crispness appears in the product The lower density crumbs impart a very crispy bite to food If porosity of breading is too low it has less crispness Excess hydrophilic colloids in batters retard the

crispness (Gums) A porous cell structure allows hot oil to enter and vaporize the all the moisture from the crumb The low moisture is a key to maintain a maximum crispness.

2.2.3 Hardness

Dense crumb, when fully fried may have an unacceptability hard texture. The normal density range of breading is from 0 6g/cm2 to 0.2g/cm2. Product densities and mesh are among the major determinants of texture. The lower density crumbs impart a Very light bite to food. The pick up potential as well as the eating sensation of the coated food can be significantly manipulated by varying the bulk densities.

2.2.4 Oiliness

The lower dense crumb have higher fat absorption where as dense crumb tends to absorb less oil when pre fried if there is insufficient fine materials to retain the oil and therefore can be seen wet surfaces A breading with a more porous or open structure not only absorb moisture more rapidly than a more dense particles, but it also exchanges that moisture for frying oil more freely Finally oil drains out more rapidly from particles that have high porosity, exhibited by a coarse, open cellular structure.

Breading with an open structure absorbs moisture and frying oil more quickly than do high density breading High-density breading should be used when maintaining a breading texture is important and little water absorption is desired

However in terms of production process home-style process is important for this project work

2.3 Home style breading

The breading made from home-style process has specific characteristics when compared with other breading types These follow the mature technology of bread making The ingredients are mixed and then dough is divided proofed and baked in to loaves These loaves are allowed to cool and then shredded and sifted to meet mess specification

Table2.1 Characteristics of homestyle breading

Breading characteristic	Home style breading
Granular shape	Spherical/ crumble
Presence of crust	High
Granular range	Wide
Mesh	4-140
Color	Variable
Browning rate	Moderate/rapid
Density	Medium
Texture	Crisp
Water absorption rate	Rapid
Oil absorption	Medium
Process suitability	Pre fry, some full fry

Table2.2 Composition of breading

Constituents (%)	Standards	Home made	Manufactured
Total solids	91.5 min	90.30	93.20
Crude fat	3.00 min	1.90	2.10
Organic non fat	89.5 min		
Ash	2.50 max		

2.4 Bread crumb ingredients

There are six major ingredients, are used for any breadcrumb formulae. Although all the basic ingredients are important, conditioners and food additives play an essential role in the breadcrumb formulae as far as its quality is concerned. The basic ingredients of the breadcrumb are the following,

1. Flour
2. Water
3 Yeast
4 Sugar
5 Salt
6 Shortening

2.4.1 Flour

Flour is finely ground endosperm of wheat. Wheat flour alone or its blend with other flours such as malt, soy, atta etc. Can be used to manufacture breading. The particle size and their distribution and presence of physically damaged starch granules effect quality of final product.

Flour contain about 9-10% protein is suitable for breading formulae. In case of high protein in the flour, breading tends to be darkening during frying whereas the flour containing lower level of protein can cause spotty coverage that gives an unappealing appearance of the final product. It is apperent that flour contains high protein level and damaged starch coming from hard wheat has high moisture retaining ability during conventional frying. In breading manufacture it is assumed that soft flour is better in to formulae than other counter parts although there are no scientific background to prove this assumption.

However in srilanka commercially available wheat flour used for all purposes is being utilized to prepare the breading formulae. In the case of higher broken levels of starch flour the formulae can be improved by adding suitable type of condreoners.

2.4.2 Water

Water is the best solvent of many ingredients used in the food industry as well as making breadcrumbs Starch granules absorb a large proportion of water Due to unique characteristics of water special care should be taken in using water for making the crumb formulae Properties like hardness in the water directly affect the quality of the dough However ion concentration in water is less effective Less percentages of water is added to initial breading formulae comparing with bread formulas.

2.4.3 Salt

Salt is added to breading formulae as flavoring agent Standard levels of application are 15g/1kg (1 5%) However the amount of salt added can vary in the range of 1-2.5%. Salt also increases the crumb colour

2.4.4 Yeast

Yeast is used to leaven the product During the fermentation Gas is generated. Commercially Yeast is available as dry/instant forms, which can be activated in 15 minutes time Yeast cells utilize the substrate getting from flour or external sources such as sugars and conditioners added to the formulae However some countries supply outside food to yeast while others do not It affects the flavors of the final product

The main disadvantage is uncontrollable fermentation process The overall reaction is in below

$$C_6H_{12}O_6 \longrightarrow CH_3CH_2OH + 2CO_2 + H_2O$$

Table2.3 Factors affecting yeast fermentation

Condition	Favorable	Unfavorable
Temperature	80 – 90°F	Below 70 and above 100
PH	4.8 – 5.4	Below 4.5 and above 5.7
Salt	Non	Above 3%
Water concentration	Dilute /slack	Concentrated stiff
Calcium propionate	Non	0.3%
KIO_2	Non	5ppm
Monocalcium phosphate	Non	0.25%
Ammonium salt	0.05 – 0.1%	Below 0.05% above 0.25%

2.4.5 Sugar

Adding of sugar is that meant for enhancing the flavours derived from the yeast rather than increasing sugar flavour itself Usually in breading formulae sugar is added in lower concentrations than required, or else is not added at all. Addition of sugar to the formulae may reduce crumb yield, due to more considerable darken outer part including crust. However addition of sugar results in desirable flavour. Sugar application level for breading is 15g/1Kg (1.5%).

2.4.6 Shortenings

The term 'shortening' baker's word is applied for fat and oils. One of the important ingredients in bakery products. These shortening affect quality of the final product. The quality parameters that the shortening reproduces in the product are the Following,

- Tenderness

  When shortening is used the crumb gets softer and easier to chew where as it is not included it becomes somewhat tough to bite.

- Lubricity

  It increases the rate of lubricity. Hence clears from the surface of mouth. Lubricity is a desirable slippery sensation in the mouth imparted by fat.

- Moist mouth feel

  This effect cannot be seen in dried crumb. But together with other ingredients it can be achieved.

Application range is 3-5%. Commonly practiced 3% level.

Ex. Trade names Superfine

Beehive

2.5 Other ingredients

In order to get the desired quality and to increase the shelf life several other ingredients are added to the formulae. They have different functionality, which affect quality more dramatically. All the ingredients applied in the crumb formulae are equally important. However the amounts of the ingredients are decided by the manufacture according to the requirement of the product. These are as follows,

- Colours
- Preservatives
- Emulsifiers
- Bread conditioners
- Eggs
- Milk powder
- Hydrocolloids
- Anti-browning agents

2.5.1 Eggs

Increase the binding capacity of batter/ breading. It also has emusifing properties. Some proteins in eggs cause undesirable colors formed during frying. Eggs can be eliminated in breading formulae without much effect. Albumin has film-forming characteristic useful for moisture retention and oil reduction during frying.

2.5.2 Colors

A colorant is a pigment used to color a product. There are two types of colors called certified and uncertified (exempt) colors. These certified colors are recognizing as Fd&c for purpose. These exempt colors are not required to certify. Certified colours are available in two forms as dyes &lakes. Dyes are more available since it is cheap and less quantity are needed to apply.

In order to have golden-brown or dark-yellow colors in final crest products many colors are used. These are added during crumb production. When we want to obtain mixed colors as mentioned above we have to go for such colors.

Widely used dyes are **FD&c** 5/6. This **FD&c** 5 gives lemon yellow color. However it is used with carmine (e 120) red gives the appearance of egg yellow. The **FD&c**6 reddish-yellow color gives appearance of orange to crumb. Application ranges are 0.01% - 0.03%. Water-soluble colors.

Other widely used colors are

- Paprika - deep red color used for backed goods & snacks
- Annato - yellow_red
- Caramel - brown
- Turmeric - lemon_yellow

Among the colours mentioned above turmeric is widely used and is the mostly available one at the market. It is natural yellow & also called curcuma is the dried ground rhizomes of several species of *curcuma longa*, a perennial herb of the zingiberaceae family. It is applied as an ingredient in mustard and its blend is used for baked goods. Usage level is 0.02% - 0.06% depending on product & desired final shade. Turmeric gives pleasing butter to egg yolk shades. Since it's a color derived from wood source during frying black patches may form.

In order to get desired colors together, with browning reaction these colors can be used. Colors are used individually or as mixed. If not colors are applied not only doesn't get desired colors but also appear dark colors during being formed in maillard reaction. Added colors suppress the appearance of these dark colors.

2.5.3 Dough conditioner

These are used to obtain good quality product, required by the consumer. It is prepared by the blending of some ingredients.

Composition of bread improver

- Ascorbic acid 100mg/kg flour
- Potassium bromide 30mg/kg flour
- L_cystein (hydrochloride) 0.5mg/kg flour
- Malt flours 2g/kg flour
- Soy flour
- Enzymes
- Flour

Table2.4 Functionality of different ingredient

Ingredient	Function
Potassium bromide Ascorbic acid	Gluten strength
L_cystein Sodium meta bisulfite	Gluten softening
Nh4Cl Phosphates Ca component	Yeast foods
Amylases Protease's	Enzyme (break down of damaged starch)
Gluten mature &crumb brightness	Enzyme active soy flour

Since the bread conditioner was introduced it has become more popular. This process is called activated dough development process. The use of l_cystein is only up to 75 PPM of the flour weight. When the chemical l_cystein is used with an oxidizing agent's rapid dough development takes place. The same thing happened as during normal fermentation.

Following are the main advantages of improver

- Special mixer is not required
- Bulk fermentation time is eliminated
- Consistent results are obtained
- No fermentation losses higher yield is obtained
- Higher volume to the loaf
- Extra softness and whiteness of the crumb structure
- Extended shelf life
- High oven spring

There are some disadvantages as well

- There is loss of flavor because of the dough does not have a fermentation period
- Increased cost

The application ranges are varies according to manufacture. When it is needed to acquire particular improvement in the product, there are certain types of conditioners.
For the breading, conditioners cause to have more porous nature, reduced bulk density & more quality characteristics.

2.5.4 Preservatives

For bakery range products, one of the severe problems is spoilage by molds
Ex. Aspergillus, rhizopes

Even though good sanitary conditions are practiced this mold growth cannot be controlled to safe counts. So need of preservatives arises. Hence uses of anti-microbial short chain acid derivatives are popular. However inhibition of microbial growth is slowly reversible and concentration dependent. Today one of the most effective & easiest preservatives is propionates/its salt. Acetates &ascorbates are effective preservatives as well.

Usage of ca/NA propionates as antimold & antirope agent for bakery product has become widely accepted. Not only because it can obtain easily as white granular or crystal powder but also it dissolves in water rapidly. This powder has a paint odor of propionic acid. Since these are chemically active agents store in a long period, expose to air & improper packaging losses their activity rapidly. Sometimes these are blend with other agents so as to get desirable results.

The applications of Ca/NA propionates harden the crumb structure. NA propionates have effect of retardation of yeast growth that leads to loss of some flavors while Ca propionates have not. However usage of higher levels retard fermentation.
Application range varies with the product. Practically higher usage is 8g/Kg.
But normally 3g/Kg are used. For sorbates it is 2.5g/Kg and effective in preventing surface spoilage. It sprays to surface.

2.5.5 Milk

Functional milk constituents of interest to bakers are milk sugars and milk protein. Milk sugars contribute to the structure, flavor and color development through browning reaction and to texture grain crumb structure. Milk proteins tenderize the product, promote moisture retention, and extend shelf life and supply food source for yeast during fermentation.

2.6 Hydrocolloids uses for oil reduction properties

There are mainly two hydrocolloids that can be recognizing as ability to reduce the oil uptake when deep-frying. Those are methylcellulose (MC) and Hydroxypropyl Methylcellulose (HPMC). These two hydrocolloids exhibit an unusual property of thermal gelation. They gel when heated and melts upon cooling, in contrast to the common gelling characteristics of pectin, carragenan, and alginates. They not only have oil reduction properties but also have improved addition strength, due to the film forming and thermal gelation properties of these gums

The major functional property that is useful in reducing oil uptake in fried foods along with film forming is thermal gelation. The MC and HPMC are the only hydrocolloids that have thermal gels, which are reversible and repeatable. The film forming can be describe as during the frying operation the swelling of starch granules release the amylose fraction and provide the film barrier that inhibits the oil penetration into and moisture loss from the substrate. The gelation temperature for MC (50-55^{0}c) is lower than for HPMC (70-90^{0}c) and gel firmness is significantly stronger in MC, however the addition of breading to these hydrocolloids for improving colour, textural and barrier properties is still existed, the batter application using gums have been most popular in the industry.

2.7 Characteristical changes in dough due to production process and ingredient

There are many changes taking place during process, which cannot be described easily Those are stale physical and chemical changes How ever for crumb production some are important to study So some of these are slightly descnbed so as to understand

(1) Functionality of some ingredients
(2) Important physical and chemical changes taking place during process
    Gelatenization
    Staling
    Gas retention on dough
    Shortening effect on dough
    Conditioner effect on dough

2.7.1 Staling of bread

Staling results mainly from the recnstelization of amylopectin During baking starch granules gelatinize The lenear amylose molecules escape (in part) from the granules and the branched amylopectin molecules expand (but they remain within the swollen granules) During cooling amylose recnstalise allowing breadcrumb to become firm enough to slicing Within several days amylopectine branches recnstelize causing granules to harden and leading to crumb firmness This process is called staling

2.7.2 Shortening effect on dough

Inclusion of fat increases the volume of baked bread Usage of 3-5 % it is happen
At 60-70 C starch granules gelatinizes at 80-90 C gluten and other fats may interact with starch and gluten to delay the reaction and that end expansion hence volume increase
Another important function of shortening is that it reduces the firmness of the bread through out the storage resulting from staling, but only for 1-3 days it increases the crumb strength
Also strength the side wall and prevent keyholes effect

2.7.3 Gelatinization

Starch exists as granules which composed of radially arranged starch molecules of leaner and branched chains The amylopectin associates with strait-chain amylose to form reagents of crystalline micelles As a result of this association through hydrogen bonding, the starch granules is insoluble in cold water, when heating provides sufficient energy to descript the week bonding between crystalline micelles the granule starts to hydrate and swell The amylose is solubelized in to solution forming an inter granular matrix which causes an increasing viscosity This takes place during 52-60 C at oven A continuous increase in temperature eventually causes the granule to calliopes and rupture The degree of hydration depends Limited Gelatinization occurs in bread due to heat application

Since there is limited water available hot all the starch will completely gelatinize It means that amount of water available effects function of starch

In addition to Gelatinization and pasting the starch in dough heat also causes permanent disulfide bonding between glutening polymers These bonds are unlike the transient bonding that occurs as dough is kneaded These heat-setting bonds affect the final step in the conversion of closed celled dough to open celled bread

2.7.4 Gas retention on dough

The good retention on gas is often occurs when dough is fully developed. So that kneading must be done until the dough is fully developed. The formation of co_2 by yeast dissolves in the aqueous phase of dough from which it diffuses into the air bubbles incorporated in the dough when it was kneaded. This converts the dough in to the foam. Expansion of these bubbles stretches the film of gluten surrounding them. This stretching is essential if the dough is to expand, as it should during baking.

Yeast dough should never be allowed to become overlight. Once the gluten strands are over stretched, they are unable to recover their original elasticity again. Dough allowed to become overlight before it is punched is unable later to retain as well the gas produced by the yeast. Such dough is slow to rise the second time and does not regain the volume it had at the end of the first rising. The result is heavy, compact loaf of low volume and poor texture. (Helen charley & Cannie weaver 1998).

When the dough is sufficiently light, it should be punched down gently. One object of punching dough is to keep the films of gluten around gas cells from being over stretched. The second object is to subdivide the gas cells that have enlarged during the fermentation period. After the dough is punched, it should be manipulated so as to avoid tearing or matting the gluten strands which bubbles of co_2 separate. Working the dough at this stage devides and increases the number of gas cells. The larger the number of gas cells, the better the distribution of co_2 in the dough and more even the grain in the baked product. Apparently, co_2 produced by yeast collects in gas cells formed in the dough as it was mixed, kneaded and shaped. However new gas cells do not form during this period.

If this dough has a tendency too sticky the surface contacted must be oiled other than applying unfermented flours. After dough is shaped it is put to pans until again dough is double in bulk. This is called proofing.

2.7.5 Conditioner effect on dough

When usage of Kbro, it increases the elasticity and reduces the extensibility of the gluten after the flour has been made to dough Ascorbic acid strengthens the gluten gas retention is thus improved and loafs volume augmented Cystine accelerates reaction within and between molecules in the dough which leads to an improvement in its viscoelastic and gas holding properties The fore said changes taken place slowly during bulk fermentation period The advantage of addition of Cystein reduces the bulk fermentation time without loosing many flavors But this is done together with other reducing & oxidizing agents

Fungal amylase starts early part of baking process attacking gelatinized starch granules. improve gas retention help dough to maintain fluid condition thus prolongs the dough expansion time and increase loaf volume Soy flours increases mixing tolerance, improve dough rhehology and its presence of lipoxygenase increase in loaf volume, crumb firmness and crust appearance

The addition of blends of these things makes the crumb more softer, porous reduced bulk density and less bulk fermentation time Use of conditioner we could get more porous more crispiness and more softy breading

Chapter 3
Experimental – material & method

3.1 Breading production

3 1 1 Material

3 1 1 1 Equipment

- Oven
- Stainless steel/ wood table
- Balance
- Basket
- Knife
- Trays
- Grinder
- Sifter
  - 8 mesh
  - 14 mesh
- Polypropylene bags
- Polysacks
- Magnetic

3.1.1.2 Ingredients

Table3.1 Ingredients

Ingredients	Normal	Sample 1	Sample 2
Flour	50 Kg	50 Kg	50 Kg
Water	27 Kg	27 Kg	27 Kg
Salt	800 g	750 g	750 g
Sugar	-	750 g	750 g
Yeast	350 g	350 g	350 g
Shortening	1 Kg	1.5 Kg	1.5 Kg
Eggs	47	12	12
Milk powder	600 g	450 g	450 g
Bread improver	-	125 g	125 g
Ca propionate	-	250 g	250 g
NA propionate	250 g	-	-
Turmeric powder	25 g	-	-
Artificial coloring	-	5 g	10 g
Methyl cellulose	-	-	100 g

3.1.2 Method

3.1.2.1 Loaves production

Flour and Ca propionate was mixed. Flour was spreaded so as to have a whole in the center. Then yeast, shortening, bread improver, eggs were spreaded in the foresaid center. Then water, sugar, salt, colouring was added and kept 15 minute until the yeast got rehydrated. If we want to add methylcellulose in to the mix, it should be rehydrated 30 minute before addition. Then shortening was smoothly dispersed manually. After that the mixture were kneaded 15-20 minute.

The dough was leavened 45 minutes (Activated dough development process was followed) Dough was divided in to 2 5Kg portions and kept 15 minutes Next these portions were rolled and put in to trays These rolls were kept in another 15 minute for proofing Then baking was done two hours at 200 c This baked loaves were kept one/two/three days so as to become harden This process was called staling

3 1 2 2 Drying

Then loaves were peeled to remove outer darker crust and broke in to piece sizes as 1 5" 1 5" 1 5" in order to be dried the crumb efficiently These pieces then were put to the trays and dried in oven for minimum 8 to 16 maximum hours at around 150 –200 c These dried crumb pieces then were packed in a polysacks until grinding

3 1 2 3 Grinding & sifting

Grinding was done using two-phase grinder in order to get desired particle size After that these ground particles were susceptible to the sifting During sift operation

- First sieved the particle through 8 mesh
- Then sieved the particles through 14 mesh

The particles that passed through 8 mesh & retained in 14 mesh is standardize as grade 1 breading use for chest range products

3 1 2 4 packaging

These graded breading were first packed in polypropylene packs These packs were put in a polysacks & these are ready for application

3.1.3 Flow chart of the breading production

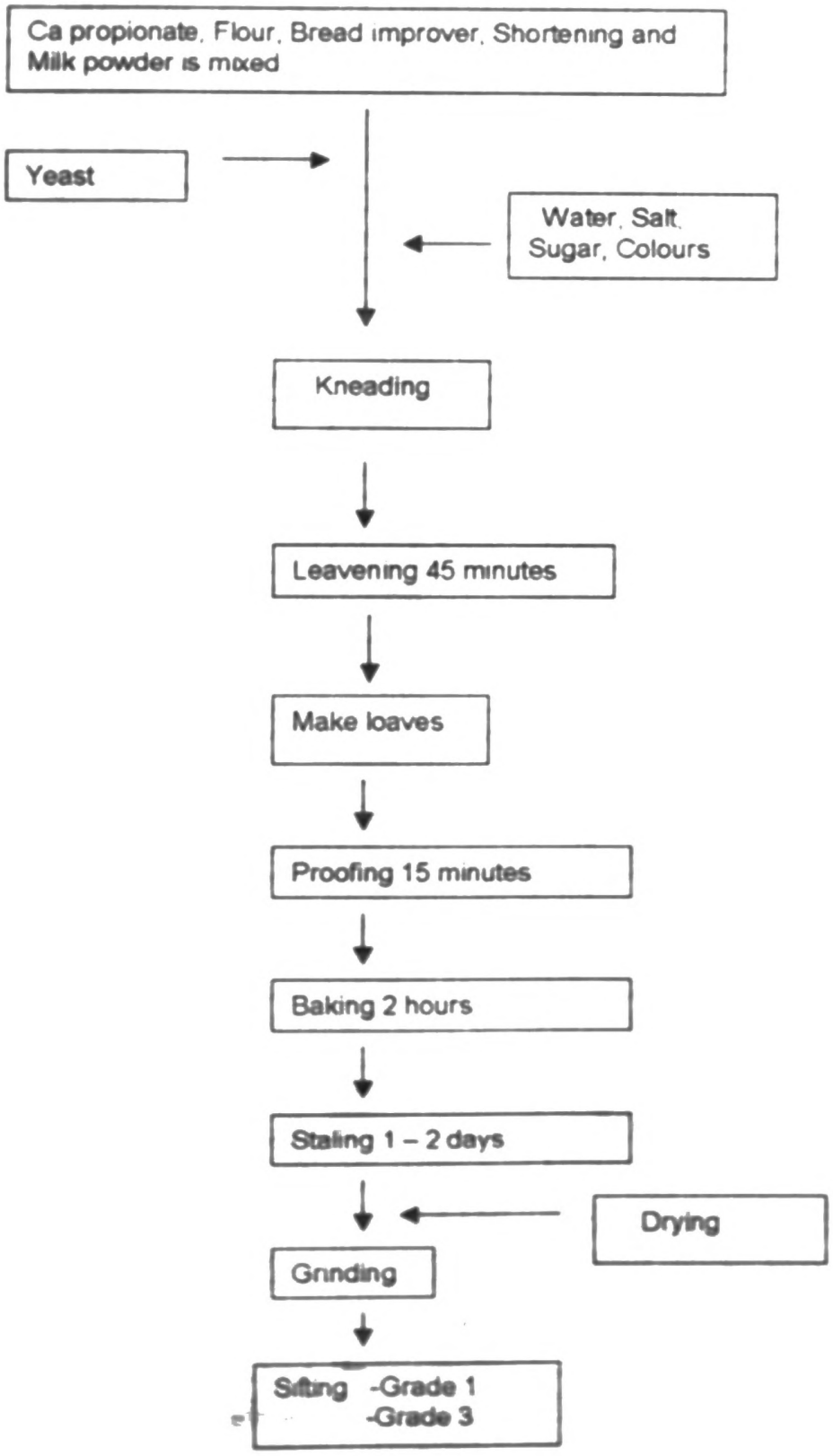

Figure 3.1

3.2 Sensory evaluation

3.2.1 Materials

- Deep fryer
- Deep frying fat
- Thermometer
- Clock
- Sauces
- Sensory evaluation sheets
- Coded numbers
- Heating oven

3.2.2 Method

3.2.2.1 Sensory evaluation 1

This was done for finding out the improvement of quality characteristics due to development of recipe.
In the production line chicken drumstick formulation was formed. For these formed products, batter was applied. After that the breading was applied to the chicken drumsticks. It was fried at 180°c for certain time. Then they were packed and kept in a cold room at -10°c for one day. Next day it was taken out from the cold room and put in a refrigerator for the test.

The second frying was done in a laboratory according to standard frying methods. The prepared products were susceptible to frying just after it was taken out from the refrigerator lest to happen freeze thaw abuse. The frying of chicken drumsticks was done at 175°c for 3 minute using deep fat frying fat agent. These fried products were only kept at 40°c heating oven for only 1 hour. During this 1 hour the sensory evaluation was carried out. The products that were held more than 1 hour in oven were thrown away due to changing of sensory properties such as crispness.

For this sensory evaluation test 3 coded samples were prepared. One was as reference and other two as numbered. The glass of water and the cream cracker biscuit was supplied with the samples. Sensory evaluation sheets were given to panelists as well. Each panelist had to give marks to samples compare with the reference sample. (Appendix2)

3.2.2.2 Sensory evaluation 2

This was done for find out the oil absorption / Hardness properties of the breading
The product was fish fingers. It was also carried out as previously described manner

3.2.2.3 Analysis of sensory evaluation data

The method used for sensory test is multiple comparison tests. It is used to examine effect of replacing or changing an ingredient; of changing process; or of storage. Small differences between the sample and the control can be detected. It also gives the direction and the magnitude of the difference. In here known reference of standard sample is labeled R and presented to panelist with several coded samples. Since it follows the normal distribution having two independent samples, it follows the

* T_test - to find out the difference between two samples / characteristics (SAS computer statistical package is used)
* Ranking test - to find out which characteristic is greater

3.3 Chemical analysis
This was done according to S.L.S. methods

3.4 Micro biological test
Mould counts were taken both for row crumbs and finished products.

3.5 Determination of bulk density
Definition
Pour an aliquot in to a container, typically 500 ml graduated cylinder and reading off the volume and calculate the density as weight per unit volume.

Volume of breading ⟶ V ml
Weight of breading ⟶ W g
Bulk density ⟶ W g / V ml
If improved sample density D1 & Normal sample density D2
Bulk density reduction percentage ⟶ $\frac{D2 - D1}{D2} * 100\ \%$

Chapter 4
Results and Discussion

4.1 Bulk density reduction percentage

Bulk density of the normal sample ⟶ 0.5675
Bulk density of the improved sample ⟶ 0.3925
(Bulk densities of 2 improved samples are almost the same)

Bulk density reduction percentage ⟶ 30.837%
(Mesh 8-14)

The decrease of bulk density of improved crumb can lead to light bite to food, improved crispness, slippery mouth feel and decrease in hardness of the crumb after frying. The 'term' porosity can be used for yeast leavened bread crumbs and describe as an open cellular network in the crumb. Due to that property and higher oil absorption foresaid describable properties can be obtained.

4.2 Improvement of sensory properties

4.2.1 Oil absorption

Table 4.1 oiliness

	Sensory 1		Sensory 2	
	NS	I S1	NS	I S2
Total scores	49	61	44 5	54
Average	2 87	3 6	3 1	3 8
T- test	No significant different at 5%		No significant different at 5%	
Rank test	-		-	

NS normal sample
I S 1/2 improved sample 1/2

Due to the increase in porosity and reduction in bulk density of the improved sample the oil absorption may be higher Due to this there is no any significant difference between two samples However with the time, oil drainage rate is higher in the improved sample It can be

observed in the sensory evaluation sheets (see appendix 3). It caused an average is higher in improved sample in sensory evaluation1.

Likewise results of the sensory evaluation 2 revealed that the use of methylcellulose in to breading and batter has not decreased the oil absorption or oiliness in product as expected. Since the effect on oil absorption, reduction properties of methylcellulose has been scientifically proved there must be some mistakes in batter formulation and breading formulation when methylcellulose is added. However use of methylcellulose in to breading formulae is less effective to the frying temperature in terms of oil absorption. (See Appendix1)

4.2.2 Crispness

Table 4.2 crispness

	Sensory 1		Sensory 2	
	NS	I S.1	NS	I.S.2
Total scores	53	65	44.5	54
Average	3.1	3.82	3 18	3.85
T-test	Significant difference at 5%		Significant difference at 5%	
Rank test	Pass		-	

NS normal sample
I S 1/2 improved sample 1/2

Crispness is one of major sensory properties required by the consumer The increase in porosity and the open cellular network helps the oil to come in and dries the crumb interior rapidly The maximum dryness helps the maximum crispness So at 5% level improved sample 1 is more crispness than the normal sample (currently used in the market) The addition of methylcellulose affects the crispness slightly, due to its moisture retention and oil barrier properties Even though the crispness of improved sample 2 and normal sample has significant difference, it can't be said that I S.2 is best as previously said (See Appendix1)

4.2.3 Colour

Table 4.3 colours

	Sensory 1		Sensory 2	
	NS	I.S 1	NS	I.S 2
Total scores	51	62	42	54
Average	3	3.6	3	3.86
T-test	No significant different at 5%		Significant different at 5%	
Rank test	-		Pass	

NS normal sample

I.S.1/2 improved sample 1/2

The addition of artificial colour has an effect on the final colour, compare with turmeric colour. Even though the addition of 0.01% artificial colours has obtained more marks it had no a significant difference. But addition of 0.02% colouring and methylcellulose has a significant difference in colour formation and hence $I.S._2$ is the best-coloured sample among others. Due to much intense colour in $I.S._2$; it was able to suppress the undesirable colours formed during browning reaction and able to give more desirable colour.

The use of methylcellulose may have increased the moisture retention and hence retard the rate of colour formation through browning reaction. Therefore finally results more desirable colour. The turmeric now uses cause some dark patches in crumb surface where as artificial colours do not. If turmeric is of colouring purposes for breading it should be used as both more purified form and much higher percentages. (Appendix1)

4.2.4 Hard to bite

Table 4.4 hardness

	Sensory 1		Sensory 2	
	NS	I.S 1	NS	I.S 2
Total scores	50	61	41.5	50
Average	2.9	3.6	2.96	3.57
T-test	No significant difference at 5%		Significant different at 5%	
Rank test	-		Pass	

NS normal sample

I.S.1/2 improved sample 1/2

One of the major problems in breading is its hard to bite property. The harder to bite breadings have higher density and less moisture content. The higher rates of staling and lower fat content are another reason. Preservatives harden the crumb as well.

The reduction of bulk density using bread improver and addition of correct amount of fat seem that the hardness of breading is reduced. But it was not significant when sensory evaluation results were analyzed. For that addition of methylcellulose has an effect of moisture retention and hence it causes significance different between improved sample 2 and the normal.

The reduction of bulk density by using bread improver, slippery mouthfeel impart by addition of correct amount of fat, and increased moisture retention due to methyl cellulose made the improved sample 2 the best for its hardness properties. It means $I.S._2$ has a very light bite properties. Because of the open cellular network in improved breading, it doesn't harden the crumb structure during frying. (Appendix1)

4.3 Shelf life

Table 4.5 microbiology results

Preservatives	T.P.C.
Ca propionates	Pass
NA propionates	Pass

The addition of Ca propionates instead of NA propionates has same effect of fungal growth inhibition, because both preservatives have almost the same effect of preservation. In addition Ca propionates help yeast to grow fast while allowing them to produce more flavours.

4.3 Overall sensory acceptability

In addition to main quality characters there are other sensory characteristics. They can be described as flavours stickiness to product, appearance etc. During sensory evaluation most positive comments were towards for improved sample. Due to addition of sugars, bread

improver as yeast foods helps to impart a more flavour substances Hence it gives more flavour

4.4 Process changes due to ingredient replacement

Table 4.6 Bulk fermentation time

Procedure	Bulk fermentation period
Existing process	2-2 5 hours
Activated dough development	45 minute

The addition of bread improver, sugar and yeast has reduced the bulk fermentation time due to activated dough development process It reduces the bulk fermentation time from 2 hours to 45 minutes Due to rapid dough development bakers must adjust their normal procedure accordingly Otherwise over fermentation can be occurred

The drying process must be done very carefully so as to avoid having over dried particles with many browning rates

Table 4 7 Yields

Breeding type	Yield (For100kg flour)
Normal grade1 sample	< 50kg
Improved grade1 sample	> 40kg

Higher porosity and less hardness affect the yield of breeding In order to increase the yield of breeding the grinder type/plate must be changed

Chapter 5
Conclusion

The newly developed breading samples have more overall acceptability The sensory results substantiate that the improved breading sample is different to market sample in terms of colour crispness and hard to bite properties significantly But the addition of methylcellulose in to batters and breading has not improved the oiliness property

The addition of 0 02% artificial colour is effective in obtaining the desirable colour formation

There is no significant difference between two preservatives used

Addition of sugar and bread improver reduces the bulk fermentation time and the bulk density

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Appendix 1

Sensory evaluation results

T-test in order to find out whether there is a significant different between samples

Sensory1

Crispness

Variances	T	DF	Prob>|T|
Unequal	2.5880	30.4	0.0147
Equal	2.5880	32.0	0.0144

For H0 Variances are equal F' = 1.61 DF = (16,16) Prob>F' = 0.3531

Colour

Variances	T	DF	Prob>|T|
Unequal	1.9522	30.8	0.0601
Equal	1.9522	32.0	0.0597

For H0 Variances are equal, F' = 1.49 DF = (16,16) Prob>F' = 0.4337

Hard to bite

Variances	T	DF	Prob>|T|
Unequal	1.8560	30.6	0.0731
Equal	1.8560	32.0	0.0727

For H0 Variances are equal, F' = 1.55 DF = (16,16) Prob>F' = 0.3869

Oiliness

Variances	T	DF	Prob>|T|
Unequal	1.9997	27.4	0.0555
Equal	1.9737	31.0	0.0574

For H0 Variances are equal F' = 2.44 DF = (16,15) Prob>F' = 0.0910

Sensory 2

Colour

Variances	T	DF	Prob>|T|
Unequal	4 1633	26 0	0 0003
Equal	4 1633	26 0	0 0003

For H0 Variances are equal, F' = 1 08 DF = (13,13) Prob>F' = 0 8957

Crispness

Variances	T	DF	Prob>|T|
Unequal	2 1872	25 7	0 0380
Equal	2 1872	26 0	0 0379

For H0 Variances are equal, F' = 1 24 DF = (13,13) Prob>F' = 0 6988

Oiliness

Variances	T	DF	Prob>|T|
Unequal	0 4579	25 6	0 6509
Equal	0 4579	26 0	0 6508

For H0 Variances are equal, F' = 1 30 DF = (13,13) Prob>F' = 0 6467

Hard to bite

Variances	T	DF	Prob>|T|
Unequal	2 6353	20 2	0 0158
Equal	2 6353	26 0	0 0140

For H0 Variances are equal F' = 3 33 DF = (13 13) Prob>F' = 0 0386

Rank test

In case there is a significant difference among the samples, the ones that are different can be determined using turkey's rank test

Method	
Finding of sample scores	A & B
Calculation of sample mean	scores/number of judgement for each Sample
If judgement are N	A/N B/N
	X Y
The sample means are arranged according to magnitude (If X>Y)	X Y
Finding of standard error	SE
Searching a table value (Treatment against D F error)	TV
Finding of L S D (Least significant difference)	SE * TV

Any two sample means that differ by L S D or more are significantly different at the 5% level

Appendix 2

Sensory evaluation sheet

Sensory evaluation of quality of crumbs

Scale for evaluation

Very much better than the reference	= 5 marks
Better than the reference	= 4 marks
Same as the reference	= 3 marks
Worse than the reference	= 2 marks
Very much worse than the reference	= 1 marks

The ... samples coded as ... & ... what was given to you, need to be evaluated against the reference for following properties,

Parameter	Code ...	Code ...
1. Colour		
2. Crispness		
3. Hard to bite		
4. Oil absorption (oiliness)		

Any other comments

_____

_____

_____

_____

_____

Checked by: .....

Appendix 3

Sensory evaluation 1 – Results

Code	Colour		Crispness		Hardness		Oiliness	
	Ns	Is_1	Ns	Is_1	Ns	Is_1	Ns	Is_1
1	2	5	2	5	3	5	2	5
2	2	2	3	3	4	4	3	3
3	3	4	3	4	3	4	3	5
4	3	4	4	5	4	4	4.5	5
5	2	4	3	3	3	4	2	4
6	2	4	3	3	2	4	2	4
7	3	4	3	4	3	4	3	2
8	3	4	3	3	1	1	3	2
9	4	3	4	2	3	4	3	3
10	5	4	3	4	3	5	3	2
11	3	2	4	4	3	3	4	5
12	4	2	2	4	4	2	4	2
13	2	4	4	4	1	3	2	5
14	3	2	2	4	3	2	2	4
15	3	4	3	5	3	4	2.5	2
16	3	5	4	3	3	3	3	4
17	4	5	3	5	4	5	3	4

Ns = Normal sample
Is_1 = Improved sample 1

Sensory evaluation 2 –Results

Code	Hardness		Oiliness		Colour		Crispness	
	Ns	Is_2	Ns	Is_2	Ns	Is_2	Ns	Is_2
1	2 5	2	2	1	4	5	3 5	4
2	4	4	3	3	3	4	4	4
3	3	3	3	3	3	3	2	3
4	3	4	3	4	3	4	3	4
5	3	4	2	4	3	4	2	5
6	3	4	4	4	4	3	4	3
7	3	4	3	3	3	4	3	4
8	3	4	3	3	3	4	4	4
9	3	3	4	2	3	4	3	4
10	3	5	1	2	2	4	4	4
11	2	3	3	3	2	3	2	3
12	3	3	3	3	3	4	3	5
13	3	3	3	3	3	4	4	2
14	3	4	3	4	3	4	3	5

Ns = Normal sample
Is_2 = Improved sample 2 (with sample batter)

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