Crackers, biscuits and cookies – processing and factors that affect quality parameters and consumer’s acceptability

Dr. Shanise Lisie Mello El Halal
CLASSIFICATION OF BISCUITS (OR COOKIES)

Formulation
- Hard dough
- Short dough

Method of processing
- Sheeting or cutting
- Rotary moulding
- Wire cutting
- Depositing

Figure 3.1 Rotary moulding roll engraving.

Figure 1.15 Rotary moulder from Dingson Food Machinery.

Figure 1.21 Baker Perkins wire-cut machine.

Products are categorized by the balance of flour, sugar, fat & water

• *High levels of sugar & fat, relative to flour*
  – Dough remains more fluid & less structure is developed

• *High levels of water & flour, low levels of sugar & fat*
  – Dough develops a firm structure by gluten development
Products are categorized by the balance of flour, sugar, fat & water


Figure 1  Biscuit composition in relation to sugar and shortening, based on 100 parts flour. (Each dough is processed according to its consistency or water content.) (Reproduced from Encyclopedia of Food Sciences and Nutrition, 2nd Edition (2003), p. 534, Elsevier Ltd.)
Crackers

- Cream crackers
- Vegetable and calcium crackers
- 'TUC' type
- Vegetable, sesame, tomato crackers
- Soda crackers
- 'Ritz' type
- Snack crackers
- Maltkist cracker
- Two-dough crackers
- Water biscuits
- Butter coconut
- Sesame crackers
CRACKERS

• Crackers are a wide range of products characterised by crispy, open texture and savoury flavours.

Products are categorized by the balance of flour, sugar, fat & water

**Formulation**
The ‘Major Ingredients’ used are:

<table>
<thead>
<tr>
<th>Crackers</th>
<th>Water</th>
<th>Sugar</th>
<th>Flour</th>
<th>Oil</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Very High</strong></td>
<td><strong>Very Low</strong></td>
<td><strong>Strong</strong></td>
<td><strong>Low</strong></td>
</tr>
<tr>
<td></td>
<td><strong>High</strong></td>
<td><strong>Medium</strong></td>
<td><strong>Medium</strong></td>
<td><strong>Medium</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Medium</strong></td>
<td><strong>Slightly Higher</strong></td>
<td><strong>Medium</strong></td>
<td><strong>Medium</strong></td>
</tr>
</tbody>
</table>
Products are categorized by the balance of flour, sugar, fat & water.

**Fig. 22.2** Relationship of cream crackers to other crackers.
TYPICAL PROCESS FLOW FOR CRACKERS

Figure 1.1 Typical process flow for crackers. Mixing and fermentation are usually batch processes, forming, baking, oil spray and cooling are continuous in-line processes.

FEATURES WHICH INFLUENCE THE BAKING PROCESS

In general, crackers may have some of the following features which influence the baking process:

● Doughs which are leavened and fermented with ingredients such as yeast, ammonia and sodium bicarbonate.

● Doughs generally have a high water content (15–25%).

● Cracker doughs are laminated (the dough sheet is made up from multiple thin layers).

FEATURES WHICH INFLUENCE THE BAKING PROCESS

- Some crackers are cut and baked in strips or complete sheets and broken into individual biscuits after baking.

- Some crackers require a colour contrast between dark blisters and a pale background colour.

Figure 3.4 Crackers cut in strips.

PROCESS FOR SNACK CRACKERS

Snack crackers are successful in every market: light and crispy with oil spray.

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flour</td>
<td>100.00</td>
</tr>
<tr>
<td>Sugar</td>
<td>8.02</td>
</tr>
<tr>
<td>High-fructose corn syrup</td>
<td>2.85</td>
</tr>
<tr>
<td>Vegetable oil (soya bean)</td>
<td>11.66</td>
</tr>
<tr>
<td>Lecithin</td>
<td>0.20</td>
</tr>
<tr>
<td>Ammonium bicarbonate</td>
<td>1.84</td>
</tr>
<tr>
<td>Sodium bicarbonate</td>
<td>1.08</td>
</tr>
<tr>
<td>Acid calcium phosphate</td>
<td>1.08</td>
</tr>
<tr>
<td>Salt</td>
<td>0.77</td>
</tr>
<tr>
<td>Enzyme</td>
<td>0.01</td>
</tr>
<tr>
<td>Water</td>
<td>29.47</td>
</tr>
</tbody>
</table>

Critical Ingredients

1. Flour should be weak with a protein content of 8–9%
2. Proteolytic enzyme.

PROCESS FOR SNACK CRACKERS

Mixing
An ‘all in’ mix on a horizontal mixer
Temperature of about 33°C for enzyme doughs.

Standing Time

Forming
The dough is laminated with four laminations, approximately 4 mm thick
No fat/flour filling is used

Figure 1.5 Baker Perkins forming line: (right to left) laminator, three gauge roll units, relaxation conveyor, rotary cutter, scrap lift and return conveyors.

Soda crackers are a traditional product in the United States, where they are made in very large volumes. Similar crackers are the Biscuits ‘Saltine’ or ‘Premium’ crackers.

Important characteristics:

- A two-stage mixing process known as ‘sponge and dough’
- A long fermentation, usually 24 hours
- Fast baking time, around 2.5 minutes, on a heavy mesh preheated oven band

PROCESS FOR SODA CRACKERS

• Critical Ingredients

• A strong flour will give an open cracker texture.

• The flour used in the sponge must be 10–11% protein.

• Stronger flour gives a harder cracker. A weaker flour (8.0–9.0% protein) is usually used for the dough and will give a product with a softer bite.

PROCESS FOR SODA CRACKERS
1.3.3 Formulation

1.3.3.1 Sponge

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flour (strong)</td>
<td>66.7%</td>
</tr>
<tr>
<td>Fresh yeast</td>
<td>0.17%</td>
</tr>
<tr>
<td>Dough fat</td>
<td>5.00%</td>
</tr>
<tr>
<td>Lecithin</td>
<td>0.53%</td>
</tr>
<tr>
<td>Malt extract 80%</td>
<td>0.95%</td>
</tr>
<tr>
<td>Water</td>
<td>28.0%</td>
</tr>
</tbody>
</table>

1.3.3.2 Dough

Sponge (follow the formulation as described in Section 1.3.3.1)

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flour (weak)</td>
<td>33.3%</td>
</tr>
<tr>
<td>Dough fat</td>
<td>5.00%</td>
</tr>
<tr>
<td>Soda</td>
<td>0.60%</td>
</tr>
<tr>
<td>Salt</td>
<td>1.50%</td>
</tr>
</tbody>
</table>

BISCUITS

Figure 1.9
HARD SWEET BISCUITS

Doughs for hard sweet biscuits have the following features:

● Doughs have strong, developed gluten which gives an elastic dough, which is sheeted and cut. It often shrinks in the first stage of baking.
● Doughs have low sugar and fat.
● Doughs have water contents typically of around 12%.

HARD SWEET BISCUITS

• Humidity in the first part of the baking is important to achieve good volume and a smooth surface sheen;

• Biscuits are baked to low moisture contents, around 1.5–3.0%.

PROCESS FOR HARD SWEET BISCUITS

Marie is a classic biscuit made throughout Europe and Asia. It has a light, crisp, delicate texture, with pale colour and clear smooth surface.

1.5.3 Formulation

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flour</td>
<td>100.00</td>
</tr>
<tr>
<td>Cornflour</td>
<td>4.41</td>
</tr>
<tr>
<td>Maize flour</td>
<td>14.70</td>
</tr>
<tr>
<td>Granulated sugar</td>
<td>25.59</td>
</tr>
<tr>
<td>Invert syrup 80%</td>
<td>7.94</td>
</tr>
<tr>
<td>Shortening</td>
<td>11.03</td>
</tr>
<tr>
<td>Lecithin</td>
<td>0.57</td>
</tr>
<tr>
<td>Salt</td>
<td>0.88</td>
</tr>
<tr>
<td>Soda</td>
<td>0.67</td>
</tr>
<tr>
<td>Acid calcium phosphate</td>
<td>0.08</td>
</tr>
<tr>
<td>Protease</td>
<td>0.02</td>
</tr>
<tr>
<td>SMS 10% solution</td>
<td>0.02</td>
</tr>
<tr>
<td>Ammonium bicarbonate</td>
<td>0.73</td>
</tr>
<tr>
<td>Water</td>
<td>26.47</td>
</tr>
</tbody>
</table>

- Medium protein flour
- Medium protein flour and contain sodium metabisulphate (SMS) to develop a soft extensible dough.

PROCESS FOR HARD SWEET BISCUITS

Critical Ingredients

1. Flour should not exceed 9.0% protein. Higher protein will result in a hard biscuit;
2. Corn flour are used to reduce the total gluten content and make a more tender eating biscuit;
3. SMS will modify the protein to make a soft extensible dough.

COOKIES

• Very soft doughs which are deposited directly onto the oven band;
• High fat and sugar recipes;
• Long baking times with relatively low baking temperatures
• High humidity is required in the first oven zones to allow the dough to spread on the oven band.

PROCCESS FOR A CHOCOLATE CHIP COOKIE

Short cookies with inclusions of chocolate chips or nuts.

1.10.3 Formulation

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flour</td>
<td>100.00</td>
</tr>
<tr>
<td>Shortening</td>
<td>55.98</td>
</tr>
<tr>
<td>Granulated sugar</td>
<td>50.05</td>
</tr>
<tr>
<td>Brown sugar</td>
<td>0.76</td>
</tr>
<tr>
<td>Whole egg powder</td>
<td>1.24</td>
</tr>
<tr>
<td>Vanillin</td>
<td>0.10</td>
</tr>
<tr>
<td>Invert syrup</td>
<td>1.24</td>
</tr>
<tr>
<td>Salt</td>
<td>0.96</td>
</tr>
<tr>
<td>Ammonium bicarbonate</td>
<td>0.29</td>
</tr>
<tr>
<td>Sodium bicarbonate</td>
<td>0.67</td>
</tr>
<tr>
<td>Chocolate chips</td>
<td>30.00</td>
</tr>
<tr>
<td>Water</td>
<td>19.14</td>
</tr>
</tbody>
</table>

INGREDIENTS

- Wheat Flour

**Wheat Gluten**

% of protein determines the flour strength

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2.2.2 Wheat Flours: Typical Specifications

<table>
<thead>
<tr>
<th>Property</th>
<th>Soft flour (%)</th>
<th>Medium flour (%)</th>
<th>Strong flour (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protein</td>
<td>8.0</td>
<td>10.3</td>
<td>13.2</td>
</tr>
<tr>
<td>Wet gluten</td>
<td>25.0</td>
<td>26.0</td>
<td>31.0</td>
</tr>
<tr>
<td>Fat</td>
<td>0.0</td>
<td>1.0</td>
<td>2.4</td>
</tr>
<tr>
<td>Carbohydrate</td>
<td>80.0</td>
<td>76.3</td>
<td>66.9</td>
</tr>
<tr>
<td>Ash</td>
<td>0.3</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>Water absorption</td>
<td>53.0</td>
<td>58.0</td>
<td>60.0</td>
</tr>
</tbody>
</table>

**Protein content:**
- Strength and elasticity
- Crackers are made with strong flour

**Starch**
- Rigidity and texture of the biscuit
- Dextrinisation = Colouring of the biscuit

**INGREDIENTS**

**Sugar**
- Sweetness
- Texture
- Inhibit starch Gelatinisation and gluten formation

**Leavening Agents**
- Yeast is normally used Used in the production of cream crackers
- The yeast is most active at temperatures of 30–35°C during
  - *Sodium bicarbonate*
  - *Ammonium bicarbonate*

INGREDIENTS

*Fats*

- Act as lubricants
- Tendetizant agent
- Provides texture/structure to the product
- Act as aerating agents
- Eating quality (palability)
- Moisture-barrier in finished products

Is Water an Ingredient?
BAKING: THE DEVELOPMENT OF THE BISCUIT STRUCTURE AND TEXTURE

Changes during the baking process

Biscuit Structure  Moisture Content  Color

- Textura
- Density/volume
- Flavour

BAKING: THE DEVELOPMENT OF THE BISCUIT STRUCTURE AND TEXTURE

Stage 1: Structure Development
Front End Heat is Critical

- Ammonia, carbon dioxide gases & water vapor are formed and released. These cause the cracker to ‘lift’.

- Dimension development
- Stack height
- Gases expand & give more ‘lift’
- Structure development
- Ammonia aroma carried away by gas bubbles
Stage 2: Moisture Removal

- Continues to remove ‘free water’ from the dough piece
- Maximum gas/dough piece expansion achieved
- Product volume relaxes
- Fixing the product structure: – Starch gelatinização – Gluten proteins change (denaturize)
- Crusting of the product surface begins

If crusting of the surface begins too early in the second stage, ‘blisters’ may result
Stage 3: Color Development

- Majority of moisture removed during Stages 1 & 2 and coloring now occurs.
- Structure is fully set and product is firm.
- The color develops due to: – Sugar caramelization – protein reactions (Maillard browning).
- These also develop flavor.
BAKING: THE DEVELOPMENT OF THE BISCUIT STRUCTURE AND TEXTURE

Figure 2.2 Wide variety of biscuit textures, densities, bites and flavours.

Figure 2.3 Variety of biscuit colours and highlighting.

Figure 2.4 After W. Mowbray.

Figure 2  Physical changes in biscuits during baking. Key: • — •, color; — —, thickness; — — • •, weight. (Reproduced from Encyclopedia of Food Sciences and Nutrition, 2nd Edition (2003), p. 537, Elsevier Ltd.)
MODES OF HEAT TRANSFER

Convection
Drying by air jets
- Dough pieces dried
- Surface of dough pieces heated
- Moisture reduced by evaporation from the surface
- Risk of checking due to moisture gradient between centre and surface

Radiation
Baking by infrared radiation
- Dough pieces baked
  (electromagnetic waves penetrate dough by +/- 4mm)
- Increased volume
- Good development of structure
- Moisture reduced from centre by conduction to the surface of the dough pieces

Conduction
Heat transfer from the oven band
- Heat transfer directly to base of dough pieces aids development of structure
- Increased lift for crackers baked on heavy mesh bands
- Good spread of cookies baked on steel bands

Figure 4.12 Summary of the effects of the modes of heat transfer.

Figure 5  Mixograph results, as a function of sucrose concentration in model doughs, revealing distinctions between cracker- versus cookie-making (Slade et al., 2006). (Color figure available online.)
QUALITY PARAMETERS AND CONSUMER’S ACCEPTABILITY

Experimental design: ONLY sugar & water levels varied, from ~10–53 Wire-Cut to ~10–50D Sugar-Snap

(A)

Sucrose conc w/w
Dough firmness
63.5%
240
72.3%
308 firmest
63.5%
94 softest
72.3%
156

S = 40
W = 23
S/W = 1.74
TOTAL = 63

S = 45.54
W = 17.46
S/W = 2.61
TOTAL = 63

S = 52.7
W = 30.3
S/W = 1.74
TOTAL = 83

S = 60
W = 23
S/W = 2.61
TOTAL = 83
QUALITY PARAMETERS AND CONSUMER’S ACCEPTABILITY

Figure 9  Cracker-baking results illustrating the primary importance of processing (in particular, dough-machining) on baking performance (Slade et al., 2006). (Color figure available online.)
QUALITY PARAMETERS AND CONSUMER’S ACCEPTABILITY

COLLAPSE AND SURFACE CRACK

Comparison of cookies with different levels of sodium bicarbonate (lb per flour cwt) using a constant level of acid in the formula to generate corresponding extents of vertical expansion during baking, in order to demonstrate that the cause of cookie surface crack is COLLAPSE, not sugar recrystallization nor surface drying.

Figure 12 Leavening agents such as sodium bicarbonate contribute to cookie collapse and surface-crack formation during baking (Slade et al., 2006). (Color figure available online.)
QUALITY PARAMETERS AND CONSUMER’S ACCEPTABILITY

EFFECT OF SUGAR TYPE: AACC 10-50D
SUGAR SNAP COOKIE BAKING \(\rightarrow\) VERY HIGH %S *

- Perfect Symmetry
- No gluten development during mixing
- Small width
- Starch gelatinization/pasting during baking
- Asymmetry \(L \ll W\)
- Gluten development during mixing
- Snap-back

* Very high %S (sugar concentration) to exaggerate sugar functionality

Figure 13  Effects of sugar type on sugar-snap cookie baking (Slade et al., 2006). (Color figure available online.)
QUALITY PARAMETERS AND CONSUMER’S ACCEPTABILITY

EFFECT OF SUGAR PARTICLE SIZE:
AACC 10-50D SUGAR SNAP COOKIE BAKING ➔ VERY HIGH %S *

Same flour, same formula, same process ..... 
Sucrose ONLY ➔ same solubility in water ..... 
So baking performance is ONLY effect of sugar particle size ..... 

Larger particle size delays sugar dissolution during mixing AND EVEN during baking !!!!
Greater starch gelatinization/pasting ➔ smaller cookie size

BUT sugar snap formula ➔ %S great enough to prevent gluten development during mixing
Danger = learn about sugar functionality, NOT flour functionality with 10-50D

Figure 15 Effect of sucrose particle size on cookie-baking performance (Slade et al., 2006). (Color figure available online.)
QUALITY PARAMETERS AND CONSUMER’S ACCEPTABILITY

Figure 4  Cookies baked from soft (left) and hard (right) wheats which differ only in their Hardness gene. Near-isogenic soft (Ha) and hard (ha) wheat lines were milled and their flours baked using a standard AACC cookie formula.
Taking the biscuit: Consumers more sensitive to sugar reductions than fat

The impact of sugar and fat reduction on perception and liking of biscuits

By Nicola Cottam 8, 03-Jun-2014
Last updated on 05-Jun-2014 at 08:42 GMT

In commercial biscuits, fat reduction is less noticeable than sugar reduction.
Fat reduction may induce a reduction in sweetness perception.
Fat or sugar-reduced biscuits perceived as less sweet are less liked than normal ones.
Fat-reduced biscuits only perceived as less fatty are equally liked as normal ones.

Fat perception is more complex than sweetness, say researchers