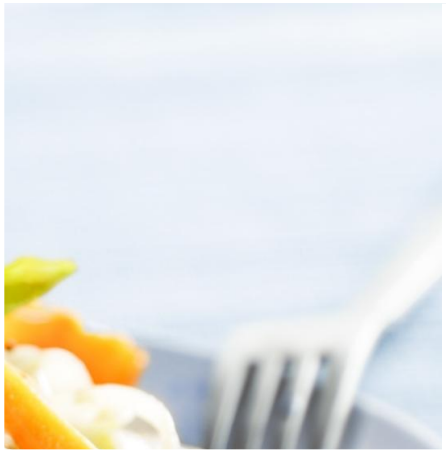
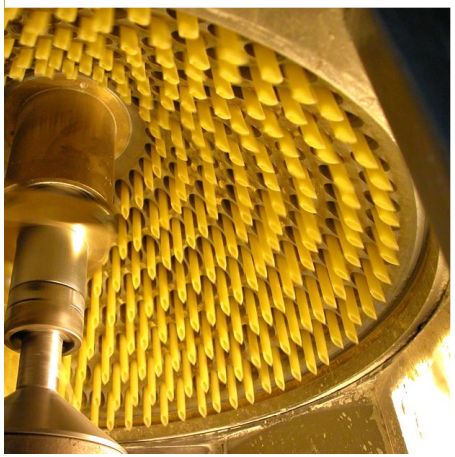



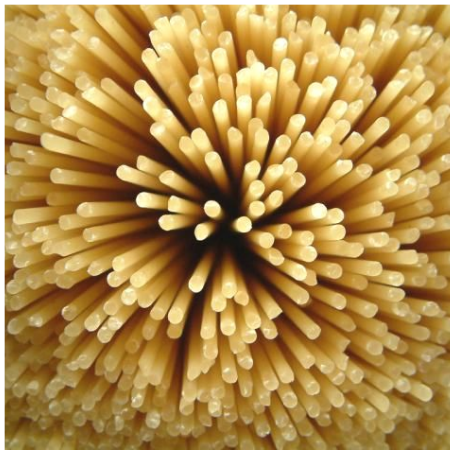


Pasta Production

NUFS 283: Food Engineering

Group 3



Preview

Introduction

- Pasta is popular because it…
  - Is nutritious
  - Is convenient to buy and prepare
  - Has a long shelf life

Inputs: Ingredients

- Semolina made from durum wheat
- Water
- Salt

Inputs: Ingredients

- Optional:
  - Eggs
  - Spinach, tomato puree, chilli, mushrooms for flavour
- Substitutes:
  - Rice, corn, spelt, kamut for semolina flour
  - Whole grain, non-grain, or soy-bean flour for semolina to make it more nutritious

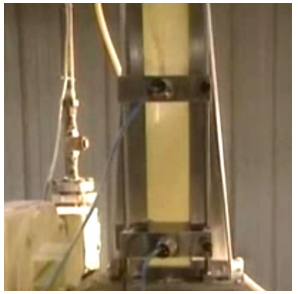
Selection of Semolina

- Semolina preferential to other flours for its
  - Particle size
  - High protein content of 13-14% dwb
  - Makes a less sticky dough during processing for easier extrusion

Combining ingredients

- Three steps involve
  - Mixing
  - Processing
  - Extruding

Combining ingredients: Pre-mixing



- Ingredients flows into mixer is regulated by a volumetric or gravimetric doser
- 0.180mm mesh sieve sifts the flour to acquire a homogeneous dough
- The flour and water is sent through a high pressure pre-mixer to hydrate the mixture

Combining ingredients: Mixing

- Bubbles are removed by a conventiona
  shaft mixer to prevent a weak and pale
  from forming
- Warm water (45-60°C) is added to bring
  moisture content of the dough to 28-32
- Spaghetti requires 16-18 minutes in the
  mixing chamber

Mixing Calculation

- Must consider energy balance of inputs in order to achieve desired properties:

$$\sum M_i \cdot \Delta h_i = M_{flour} \cdot \Delta h_w + M \cdot E_m - Q_j$$

$$\Delta h_w = 15.1 \text{ kJj/kg}$$

Combining ingredients: Extrusion

- Gluten matrix develops, assuming dough was sufficiently hydrated

Extrusion

- An extruder _____ the dough.
  - Convey
  - Compacts
  - Kneads
  - Relaxes
  - Extrudes

Extrusion

- Hydrated semolina mixture drops directly onto the extrusion screw
- Screw brings mixture to extrusion barrel, where it is compacted
  - Pressure increase from to 2 MPa to form a compact dough
- Screw continues to move dough along to extension plate

Extrusion: Challenges yet

- Difficult to form uniformly kneaded dough
  - Solution: apply a kneading plate
- Friction between the walls, barrel, and screw increases the temperature of dough

$$T_{remove} = (T_{Frictional} + T_{Extrusion\ screw})°C - 45°C$$

(Specific Mechanical Energy) $SME = \frac{E_{transfer\ to\ pasta}}{m_{pasta}}$

$$T_{frictional\ heat} = \frac{SME}{Cp}$$

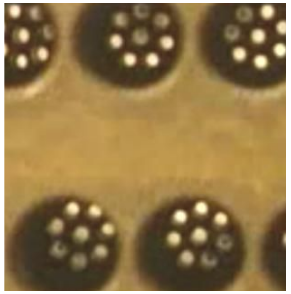
$$Cp = 1.44 + 2.74X_w$$

- Ideal temperature: 45 - 50°C
  - 50°C impedes gluten matrix formation
  - Too cool will yield a dough with undesirable viscosity

Extrusion

- Long pasta, like spaghetti are allowed a brief rest before entering the die in the extension tube
- The pasta will be fully developed by the time taken to reach the end of the extension tube

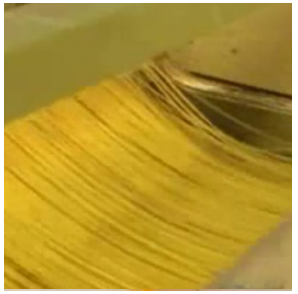
Extrusion



- Die is used with an insert to shape pasta
- Shape of insert determines shape of pasta
  - Circular for spaghetti
- Inserts are coated with Teflon to decrease friction and increase rate of extrusion
  - Also prevents pasta from absorbing water while being cooked

Extruder output = drag flow - pressure flow - leakage flow

Extrusion



- Long pastas are left to stand on a spreader which cuts them into uniform lengths
- Trims result from uneven flow out from the die
  - Are collected and brought back to mixer via trim return system
- Pastas are then attached to sticks are transfer to dryer

Drying

- Purpose: to reduce moisture content to 12% to extend shelf life
  - Limits bacterial growth
- To determine the amount of water to be evaporated:

$$MC_{wb}\,\% = \frac{\text{Mass of water}}{\text{Mass of solids} + \text{Mass of water}} \times 100\%$$

Drying

- Four factors involved:
  - Humidity
  - Temperature
  - Time exposure to heat
  - Air flow
- Air flow and time exposure affects humidity and temperature

Drying: Air flow

- Direct contact between air and the pasta enables the most efficient method of drying due to the greater surface area

Drying: Humidity

- Wet hot air (40-70% w/w)
- Prevent product from cracking at high temperatures

Drying: Exposure Time

- High temperatures requires shorter exposure time
  - Rapid drying may form cracks in the dough and result in a brittle the final product
- Low temperatures requires longer exposure time
  - Moulds development, especially on the inner parts

Drying: Temperature

- Needs to be regulated because
  - Too high: damage product and destroy nutrients
  - Too low: expensive and inefficient
- Ranges from 32-110°C
- Spaghetti
  - Pre-dried with gradual increase 30-56°C
  - Dried by gradual increasing from 56-72°C

Drying: Temperature Regulations

- Short pastas are regulated by:
  - Being on a shaking pre-dryer to decrease time exposure to high temperature in drier
- Long pastas are regulated by:
  - Pre-dried with blast of air for 30-60 minutes
  - Dried at 55-82°C
  - Cooled in a cooling chamber by indirect water contact at 28-32°C for 1.5 hours

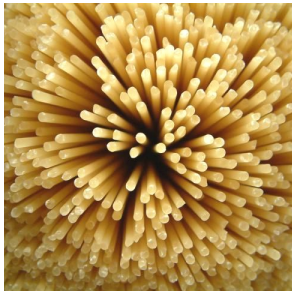
Use of Ultra High Temperature

- Application of Ultra-High Temperature
  - May cause non-enzymatic browning
  - May result in lysine and vitamins losses
  - Shortens drying time of spaghetti from 12 hours to 4.5 hours
  - Result in product with better cooking properties
  - Greater expression of yellow in product

Improper cooling?

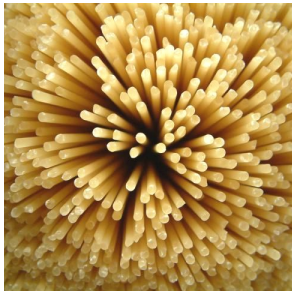
- Damage the packaging
- Contaminated product
- Brittle product

Nutritional and Sensory Quality



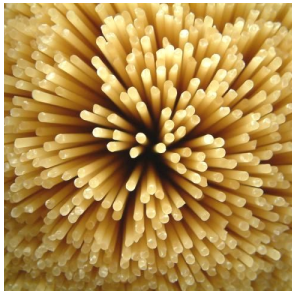
- Nutritious
  - Carbohydrates
  - Protein
  - Vitamin B
  - Iron
  - Folic acid
  - Not fattening itself

Nutritional and Sensory Quality



- Ideal food for diabetics, especially whole grain products
  - Slow digestion
  - Maintains steady glucose levels
  - Gradual insulin release
- Because of the limited surface area for α-amylase
  - Tight protein structure
  - Limited porosity
  - With cooking, swelling of pasta restricted by tight gluten matrix and oligosaccharides

Nutritional and Sensory Quality



- Yellowness of pasta determine by
  - Adding eggs
  - Adding β-carotene (most times)
- β-carotene (vitamin A precursor)
  - Prevents many diseases
  - Immune function
  - Vision
    - Processing makes this more bioavailable

Nutritional and Sensory Quality

- Cooking should not exceed >50°C
  - Damage gluten matrix
  - Loss of lysine, vitamins, furosine
- Mixing and extruding under pressure
  - Decrease beta-carotene oxidation
- Water increase calcium and copper slightly

Summary

- Mixing, extruding, and drying are required in pasta processing
- Extrusion process forms gluten network
  - Useful in forming desirable structure for shaping and cooking
  - Gluten also helps retain nutrients

Summary

- Drying creates a moisture gradient
  - Reduces required drying energy, temperature, and time
- Drying requires attention in order to ensure safety and maintain nutrients
  - Shelf stable product
  - Preserve nutrients in gluten matrix

Photo References

- http://www.food-info.net/images/pasta/pasta.jpg
- https://files.nyu.edu/avl236/public/Flat%20Noodles.jpg
- https://files.nyu.edu/avl236/public/pasta.JPG
- http://bombaybazar.ie/images/semolina-19582.jpg
- http://thinkcommon.com/blog/wp-content/uploads/2009/05/water.jpg
- http://www.wholesaleitalianfood.com/media/catalog/category/file_6.JPG
- http://www.italgi.it/foto/extrspag1.jpg
- http://www.klaroudaseeds.com/wheat-Thur06.jpg
- http://images.google.ca/imgres?imgurl=http://www.freshpastamachines.co.uk/images/lillo_dies.jpg&imgrefurl=http://www.freshpastamachines.co.uk/lillo_due_pasta_machine.html&usg=__zGyw76D9SF_rMXa9AoGFgLEITJg=&h=302&w=320&sz=33&hl=en&start=47&itbs=1&tbnid=YToJZz90WcMP6M:&tbnh=111&tbnw=118&prev=/images%3Fq%3Dpasta%2Bextruder%26start%3D36%26hl%3Den%26client%3Dfirefox-a%26sa%3DN%26rls%3Dorg.mozilla:en-GB:official%26gbv%3D2%26ndsp%3D18%26tbs%3Disch:1