Legume-enriched Pasta
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**Legume-enriched Pasta:** how structure impacts starch and protein digestibilities and protein allergenicity

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**Interest of Mixing Durum Wheat and Legume in pasta**

Inspired by The Mediterranean diet and its health benefits

Wheat & Legume Well represented

But Legume-enriched Pasta: how structure impacts starch and protein digestibilities and protein allergenicity

Macroscopic structure of dry and cooked pasta

- **Porosity (μm)**
  - 100% Durum wheat: 3.4
  - 35% Split pea: 5.9
  - No effect

- **Rheology (TAXTplus)**
  - 100% Durum wheat: Min = 0.98
  - 35% Split pea: Min = 0.65
  - Min = 0.06

**Microscopic structure of cooked pasta**

- **Starch**
  - Naked starch
  - Starch granules

- **Fibres**
  - Soluble fibres

- **Proteins**
  - Gluten
  - Legume proteins

- **Allergenicity**
  - Presence of IgE-reactive fragments in digestion juices: inhibition ELISA, pools of sera from allergic patients to wheat or to pea

**Durum wheat pasta structure**

**Methodology**

**PASTA STRUCTURE**

- **GLYCEMIC INDEX**
  - in vitro starch digestibility

- **Macromolecular**
  - Porosity
  - Rheology

- **Microscopic**
  - Starch
  - Fibres

- **Supramolecular**
  - Protein interactions

**Impact of legume flour addition**

100% Durum wheat pasta (control) 35% Split pea pasta

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35% legume fortified pasta: higher protein and fibre contents

**Structure/ Nutrition: what is known on durum wheat pasta**

**Pasta structure and nutritional properties:** impact of Legume addition and changes in process

100% Durum wheat pasta: a low glycemic index (GI) food

**Process**

- **Freezing-drying**
  - LT-dried (5°C) Control
  - VHT.LM (90°C)

**Main hypothesis**

- Pasta compactness (Foulds et al., 2000; Grondel et al., 1999)
- Encapsulation of starch by proteins (Galliano et al., 1989; Foulds et al., 2000)
- Physical structure of starch (Kohyama, 2009; Englyst et al., 1992; Holm et al., 1988)

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Supramolecular structure of cooked pasta

- 3D-APBC after protein extraction

- Freeze-drying: idem than LT-dried pasta

- VHT-LM: proteins linked by covalent bonds

Impact of drying treatments

5% Split pea

Macromolecular structure of dry and cooked pasta

<table>
<thead>
<tr>
<th>Pasta type</th>
<th>Total porosity (%)</th>
<th>Freeze-drying LT</th>
<th>Freeze-drying VHT-LM</th>
</tr>
</thead>
<tbody>
<tr>
<td>LT</td>
<td></td>
<td>5.6</td>
<td>4.5</td>
</tr>
<tr>
<td>VHT-LM</td>
<td></td>
<td>5.6</td>
<td>4.5</td>
</tr>
</tbody>
</table>

Rheology

Compression test

Tension test

Microscopic structure of cooked pasta

Starch

Proteins

Effect of drying

No major impact

Pasta samples

Rapidly available glucose: RAG value

Pasta samples | RAG value | % Available carbohydrates
<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>100% Durum wheat</td>
<td>0.25 ± 10^-4</td>
<td>62.5 ± 1.0</td>
</tr>
<tr>
<td>35% Split pea</td>
<td>0.5 ± 1.1</td>
<td>59.4 ± 1.1</td>
</tr>
</tbody>
</table>

No change in the in vitro starch digestibility (RAG)

No effect of structural modifications made by pasta fortification with 35% of legume flour on the RAG value

In vitro starch digestibility of cooked pasta

Freeze-drying LT: 35% Split pea

VHT-LM: 35% Split pea

Degree of Proteine hydrolysis (% n=3)

Freeze-drying LT: Strengthened pasta structure

VHT-LM: No major impact

No significant difference

Microscopic structure of cooked pasta

Starch

Proteins

Effect of drying

No major impact

Pasta fortification with 35% of legume changed both

- the in vitro protein digestibility

- the in vitro allergenicity of digestion juices (nature and quantity of released fragments)
In vitro allergenicity of digestion juices of cooked pasta

ELISA inhibition with allergic sera - presence of IgE-reactive fragments (IgE-RF)

<table>
<thead>
<tr>
<th>Protein fractions</th>
<th>Percentage inhibition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freeze-dried</td>
<td>0%</td>
</tr>
<tr>
<td>VHT.LM</td>
<td>20%</td>
</tr>
<tr>
<td>Pasta</td>
<td>40%</td>
</tr>
<tr>
<td>Gastric juices</td>
<td>60%</td>
</tr>
<tr>
<td>Intestinal juices</td>
<td>80%</td>
</tr>
</tbody>
</table>

Conclusions (1)

- **COMPOSITION**
  - More fibres: Non-gelatinised starch at the core
  - Weaker protein network: Different IgE-RF from some wheat proteins (γ-gliadins, LTP...)

Conclusions (2)

- **Structural elements involved in starch digestibility**
  - Pasta porosity: YES
  - Protein network thickness: No change.
  - Nature & quantity of interactions between proteins: YES

Conclusions (3)

- **Hypothesis**: A highly aggregated protein network would be more resistant to protein hydrolysis, which could delay hydrolysis of starch by amylases

Design of foods made from durum wheat and legumes: How the association of their components contributes to their nutritional and organoleptic properties.