Legume-enriched Pasta
Maud Petitot, Chantal Brossard, Cecile Barron, Colette Larre, Marie Helene Morel, Evelyne Paty, Brigitte Nicolie, Valérie Micard

To cite this version:

HAL Id: hal-02818916
https://hal.inrae.fr/hal-02818916
Submitted on 6 Jun 2020

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L’archive ouverte pluridisciplinaire HAL, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d’enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.
Legume-enriched Pasta: how structure impacts starch and protein digestibilities and protein allergenicity

M. Petitot, C. Brossard, C. Barron, C. Larrié, M.H. Morel, E. Paty, B. Nicolie, V. Micard

UMR INRA, SupAgro, Montpellier
CHU Necker, Paris
CHU Angers, Angers

Inspired by The Mediterranean diet and its health benefits

Pasta composition

<table>
<thead>
<tr>
<th>Protein (% db)</th>
<th>Starch (% db)</th>
<th>Fibres (% db)</th>
</tr>
</thead>
<tbody>
<tr>
<td>13.3</td>
<td>67.6</td>
<td>9.1</td>
</tr>
<tr>
<td>16.1</td>
<td>67.6</td>
<td>6.5</td>
</tr>
</tbody>
</table>

35% legume fortified pasta: higher protein and fibre contents

Impact of legume flour addition

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

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

Macroscopic

- Pasta compactness (Pfund et al., 2009; Grochol et al., 2011)
- Encapsulation of starch by proteins (Cosentino et al., 1996; Fundt et al., 1996)
- Physical structure of starch (Fletcher, 2006; Elghazali et al., 2002; Mellefont et al., 2000)

100% Durum wheat: GI 100
35% Split pea: GI 53

Starch granules

Gluten network

Fibres

Proteins

Starch and protein digestibilities

100% Durum wheat (control)
35% Split pea (LT-dried)

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

Methods

PASTA STRUCTURE

GLYCEMIC INDEX

in vitro starch digestibility

GLC

Microscopic

- Porosity
- Rheology

Supramolecular

- Protein network
- Starch
- Fibres

Protein interactions

ALLERGENICITY

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

100% Durum wheat pasta
35% legume fortified pasta

Pasta structure

Microscopic structure of cooked pasta

Starch

Fibres

Proteins

Legume fortified pasta

35% legume fortified pasta: higher protein and fibre contents

100% Durum wheat
35% Split pea

Legume effect: higher hardness and lower breaking energy

Mechanisms of increased protein digestibility

Amylase

Proteins

Gliaidins

Glutenins

Starch digestibility

Protein

Structural protein conformation

Gliaidins

Glutenins
Supramolecular structure of cooked pasta

SE-HPLC after protein extraction:
- Non covalent bonds
- Covalent (S-S)
- Other covalent bonds

Legume pasta:
- Weaker protein network

Covalent (others)

Non covalent bonds

Covalent (S-S)

% of total protein content:
- 0
- 10
- 20
- 30
- 40
- 50
- 60
- 70
- 80

Durum wheat
- 35%

Split pea
- 35%

Rapidly available glucose: RAG value

<table>
<thead>
<tr>
<th>Pasta samples</th>
<th>RAG value</th>
<th>% Available carbohydrates</th>
</tr>
</thead>
<tbody>
<tr>
<td>100% Durum wheat</td>
<td>47.2 ± 4.2</td>
<td>22.5 ± 1.6*</td>
</tr>
<tr>
<td>35% Split pea</td>
<td>35.4 ± 2.4*</td>
<td></td>
</tr>
</tbody>
</table>

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

No change in the in vitro starch digestibility (RAG).

In vitro starch digestibility of cooked pasta

RAG value

% Available carbohydrates

100% Durum wheat
- 47.2 ± 4.2

35% Split pea
- 35.4 ± 2.4*

In vitro Protein digestibility and allergenicity

Degree of Protein hydrolysis (%, n=3)

<table>
<thead>
<tr>
<th>Protein fractions</th>
<th>Freeze-drying LT</th>
<th>Freeze-drying VHT.LM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plasticine</td>
<td>56.8%</td>
<td>46.8%</td>
</tr>
<tr>
<td>Filtrate</td>
<td>53.8%</td>
<td>43.8%</td>
</tr>
<tr>
<td>Remaining protein</td>
<td>88.1%</td>
<td>76.8%</td>
</tr>
</tbody>
</table>

Freeze-drying LT: idem than LT-dried pasta

VHT.LM: proteins linked by covalent bonds

Impact of drying treatments

35% Split pea

Freeze-drying LT (55°C) CONTROL

VHT.LM (90°C)

Macroscopic structure of dry and cooked pasta

Total porosity (%)

Freeze-drying LT

Freeze-drying VHT.LM

Rheology

Compression test

Tension test

Microscopic structure of cooked pasta

Starch

Proteins

Frozen-drying LT

VHT.LM

Effect of drying

No major impact

Supramolecular structure of cooked pasta

SE-HPLC after protein extraction:
- Non covalent bonds
- Covalent (S-S)
- Other covalent bonds

Freeze-drying LT (55°C) Control

VHT.LM (90°C)

In vitro starch digestibility of cooked pasta

Rapidly available glucose: RAG value

<table>
<thead>
<tr>
<th>Protein fractions</th>
<th>Freeze-drying LT</th>
<th>Freeze-drying VHT.LM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plasticine</td>
<td>56.8%</td>
<td>46.8%</td>
</tr>
<tr>
<td>Filtrate</td>
<td>53.8%</td>
<td>43.8%</td>
</tr>
<tr>
<td>Remaining protein</td>
<td>88.1%</td>
<td>76.8%</td>
</tr>
</tbody>
</table>

Freeze-drying LT: idem than LT-dried pasta

VHT.LM: proteins linked by covalent bonds

In vitro Protein digestibility of cooked pasta

Degree of Protein hydrolysis (%, n=3)

<table>
<thead>
<tr>
<th>Protein fractions</th>
<th>Freeze-drying LT</th>
<th>Freeze-drying VHT.LM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plasticine</td>
<td>56.8%</td>
<td>46.8%</td>
</tr>
<tr>
<td>Filtrate</td>
<td>53.8%</td>
<td>43.8%</td>
</tr>
<tr>
<td>Remaining protein</td>
<td>88.1%</td>
<td>76.8%</td>
</tr>
</tbody>
</table>

Freeze-drying LT: idem than LT-dried pasta

VHT.LM: proteins linked by covalent bonds

Freeze-drying: No significant difference

VHT.LM: Stronger protein network at a supramolecular level
**In vitro allergenicity of digestion juices of cooked pasta**

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

**Conclusions (1)**

**COMPOSITION**

- More fibres
- No-gelatinised starch at the core

**PROCESSING**

- Freeze-drying: More fibres, No gelatinisation of starch at the core
- VHT.LM: Changes concerned wheat proteins (γ-gliadins, LTP...)

**Nature & quantity of interactions between proteins:**

- Yes

**Structural elements involved in starch digestibility:**

- Protein network thickening: No changes
- Pasta porosity: Yes

**Protein network thickness:**

- No changes

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

**Conclusions (2)**

**Conclusions (3)**

**Protein network thickness:**

- No changes

**Pasta porosity:**

- No

**Nature & quantity of interactions between proteins:**

- Yes

A highly aggregated protein network would be more resistant to protein hydrolysis, which could delay hydrolysis of starch by amylases.