LWT - Food Science and Technology 79 (2017) 471–478

Contents lists available at ScienceDirect

LWT - Food Science and Technology

journal homepage: www.elsevier.com/locate/lwt

How the structure, nutritional and sensory attributes of pasta made from legume flour is affected by the proportion of legume protein

Karima Laleg [a, b], Cécile Barron [a], Sylvie Cordelle [c], Pascal Schlich [c], Stéphane Walrand [b], Valérie Micard [a, *]

[a] UMR IATE, Cirad, Inra, Montpellier SupAgro, Université de Montpellier, F-34060 Montpellier, France
[b] CRNH Auvergne, UNH, UMR 1019, Inra, F-63000 Clermont-Ferrand, France
[c] Centre des Sciences du Goût et de l'Alimentation, CNRS, INRA, Univ. Bourgogne Franche-Comté, F-21000 Dijon, France

ARTICLE INFO

Article history:
Received 10 October 2016
Received in revised form
23 January 2017
Accepted 25 January 2017
Available online 27 January 2017

Keywords:
Protein network structure
Cooking quality
In-vitro protein digestion
Trypsin inhibitory activity
Sensory analysis

ABSTRACT

In this study, wheat in pasta was partially or completely replaced by faba to increase its protein quantity and improve its quality. Increasing the ratio of faba:wheat protein from 0:100 to 100:0 (g/g) in pasta enlarged its protein network at the microscopic scale and linearly diluted the covalently linked gluten network of wheat pasta by weakly linked proteins. A concomitant linear increase in the cooking loss (up to 2.6 fold), a decrease in resilience (up to 1.4 fold) and an increase of the *in-vitro* protein digestion (up to 25%) were observed in pasta. The increase in drying temperature (90 °C vs. 55 °C) promoted the covalent aggregation of proteins in all pasta, but was more efficient in legume pasta, enhancing their resilience and reducing their cooking loss, without altering the degree of protein hydrolysis. This was partly explained by the reduction in trypsin inhibitory activity in all legume pasta dried at 90 °C. Interestingly, scores for sensory attributes such as liking attributed to pasta containing 80% faba-protein were close to scores given to a commercial whole wheat pasta. Pasta made exclusively from faba dried at 55 °C or 90 °C tended to be liked more than their commercial gluten-free counterparts.

1. Introduction

Consumer demand for an alternative to meat proteins in the diet has been increasing in recent decades. The potential of legumes such as faba to partly replace meat intake in the human diet was reviewed by Multari, Stewart, and Russell (2015). In addition, the association of wheat and legumes in the same food helps benefit from the nutritional composition of both crops, notably their complementary essential amino acid profile (Duranti, 2006). Among several traditional wheat products, pasta is an appropriate base for this association because of its palatability, low cost and wide consumption. Legume-wheat mixed pasta with 50% of faba protein has been demonstrated to have a better essential amino acid profile than classical wheat-gluten or wheat-egg enriched pasta at identical protein content (Laleg, Barron, Sante-Lhoutellier, Walrand & Micard, 2016) with a conserved low glycemic index (Greffeuille et al., 2015). However, the total amount of essential amino acids required by the body has not yet been reached in pasta (Laleg, Barron et al., 2016) because of technological problems that arose when more than ~50% legume protein was included in the pasta (Petitot, Boyer, Minier, & Micard, 2010b; Wood, 2009). Two recent studies demonstrated that it is now possible to overcome the 50% threshold in legume protein in pasta and that it is even possible to produce pasta with legume as the only source of proteins (Laleg, Cassan, Abecassis & Micard, 2016; Rosa-Sibakov et al., 2016). These completely gluten-free legume pasta could be of interest for celiac patients, or for people who wish to reduce or eliminate gluten from their diet.

However, including legume protein in pasta can also have unexpected nutritional and sensory effects. Legumes contain some protease inhibitors such as trypsin inhibitors, which can alter the digestibility of proteins (Duranti, 2006) but could be partially or totally inactivated by thermal treatment of legume pasta (Laleg, Cassan, Barron, Prabhasankar, & Micard, 2016; Zhao, Manthey,

Abbreviations: °H, degree of hydrolysis; DTE, dithioerythritol; F, faba; LT, low temperature; OCT, optimal cooking time; SDS, sodium dodecyl sulphate; SE-HPLC, size exclusion-high performance liquid chromatography; S-GF, gluten-free spaghetti; S-WW, whole wheat spaghetti; TDS, temporal dominance of sensation; TIA, trypsin inhibitory activity; VHT, very high temperature; W, Wheat.

* Corresponding author. JRU-IATE, 2 Place Pierre Viala, 34060 Montpellier, France.
E-mail address: valerie.micard@supagro.fr (V. Micard).

http://dx.doi.org/10.1016/j.lwt.2017.01.069
0023-6438/

Chang, Hou, & Yuan, 2005). In addition, it has been reported that beyond 28% of gluten protein substitution with legume protein, cooking properties and sensory acceptance of pasta are reduced (RayasDuarte, Mock, & Satterlee, 1996). This was attributed to the dilution or the absence of the gluten network responsible for the pleasant organoleptic and cooking quality of pasta. The use of high temperature to dry pasta has been shown to prevent the alteration of cooking, textural and organoleptic properties of classical and low legume protein (<50% of total protein) enriched pasta by promoting covalent links between proteins (Laleg, Barron et al., 2016). However the effect of drying temperature on pasta with higher level of legume protein substitution has not yet been studied.

The aim of this work was to study the impact of the percentage (0%–100%) of enrichment using legume protein (faba) in pasta and the impact of drying temperature (low temperature, LT, vs. very high temperature, VHT) on pasta structure and its resulting textural and cooking properties. The effects of changes in pasta formulation and/or processing on trypsin inhibitory activity and on its protein network structure and resulting *in-vitro* digestibility were analyzed. Pasta with the best textural, cooking and/or nutritional qualities was subjected to consumer acceptance analyses and compared to a commercial gluten-free and a whole wheat counterpart for the first time using the Temporal Dominance of Sensations test.

2. Material and methods

Wheat semolina (W) and faba flour (F) were supplied by Panzani (Marseille, France) and GEMEF industries (Aix-en-Provence, France), respectively. W and F contained, on a dry basis, 13.1 and 24.0 g/100 g of proteins, 77.8 and 57.6 g/100 g of starch, and 2.4 and 11.7 g/100 g of fibers, respectively. The particle size distribution (D50) of W-semolina and F-flour was 252 and 25 μm, respectively. Whole wheat spaghetti (S-WW; Celnat, Saint-Germain-Laprade, France) and gluten-free spaghetti (S-GF; Schär, Burgstall, Italy) made from maize, millet and rice were purchased from a local French market and used to evaluate the sensory attributes of our pasta.

2.1. Pasta production

Pasta containing 0 (F0), 50 g (F50), 80 g (F80) and 100 g (F100) of faba protein per 100 g of total protein were produced using a mixture of W-semolina and F-flour at W:F (g/g) ratios of 100:0, 65:35, 30:70 and 0:100, respectively. Pasta formulation and composition are detailed in Table 1. F0 and F50 pasta were processed into spaghetti as described by (Petitot, Boyer et al., 2010). F80 and F100 pasta were produced according to the WO2016097328A1 patent (Laleg, Cassan et al., 2016). F0, F50, F80 and F100 were hydrated to 47, 45, 43 and 42 g/100 g (db) respectively, mixed for 20 min and extruded using a continuous pilot-scale pasta extruder (Bassano, Lyon, France). All the pasta were dried at low temperature 55 °C (LT) or at 90 °C (VHT) in a pilot-scale drier (AFREM, Lyon, France). The diameter of the dried pasta was 1.56 ± 0.03 mm for F0 and F50, 1.51 ± 0.01 mm for F80 and 1.47 ± 0.03 mm for F100 pasta. The total protein content of the dry pasta was determined in duplicate using the Kjeldahl procedure (NF V 03-050, 1970) with a conversion factor of 5.7 for wheat and of 6.25 for faba proteins. Lysine and cysteine amino acids were determined in duplicate on dry pasta at CIRAD (Montpellier, France) according to Moore, Spackman, and Stein (1958). Pasta composition is detailed in Table 1.

2.2. Molecular structure of the protein network of dried pasta

The extraction procedure of pasta protein was performed according to Morel, Dehlon, Autran, Leygue, and Bar-L'Helgouac'h (2000). Samples of dried pasta were ground and proteins were extracted in triplicate from the raw mixtures used for pasta production (100% semolina, 65% semolina + 35% faba, 30% semolina + 70% faba and 100% faba) and from ground pasta. The first extraction was performed in sodium dodecyl sulphate (SDS, 0.1 mol/L) to disrupt the electrostatic, hydrophobic and hydrophilic interactions between proteins. After centrifugation, the pellet was subjected to a second extraction in SDS (0.1 mol/L) + dithioerythritol (DTE, 0.02 mol/L), and sonicated (Vibracell 72434, Bioblock Scientific, Illkirch, France) at 50% and at a frequency of 20 kHz for 5 min to disrupt disulfide linked proteins. The protein size distribution of each extract was studied by size exclusion (SE)-HPLC (Morel et al., 2000). Areas (in arbitrary units) of SDS-soluble and DTE-soluble proteins were added and the sum (i.e. total extractable proteins) was expressed as a percent of the corresponding total area calculated for W-semolina (for F0), for blends of semolina and F-flour with 50% and 80% protein from F-flour (for F50 and F80, respectively), or for F-flour (for F100). The remaining pellet made of non-extractable proteins represented proteins linked by covalent linkages that were not affected by sonication and/or DTE (e.g.: isopeptide bonds).

2.3. Cooking and textural properties of pasta

Each pasta was cooked to its own optimal cooking time (OCT) in demineralized water containing 7 g/L of salt according to the AACC approved method (66-50), and then left to rest for 10 min in a

Table 1
Formulation of pasta and protein composition of pasta made from different mixtures of wheat (W) semolina and F (faba) flour; and the lysine and cysteine contents of pasta dried at low temperature (LT) and very high temperature (VHT).

Amounts of raw materials (g/100 g, db)	F0	F50	F80	F100
W-semolina	100	65	30	0
F-flour	0	35	70	100
Protein composition				
Total protein content (g/100 g of pasta, db) [a]	13.1 ± 0.0	16.9 ± 0.1	20.7 ± 0.0	24.0 ± 0.1
W-protein (g/100 g of pasta, db) [b]	13.1	8.5	3.9	0.0
F-protein (g/100 g of pasta, db) [b]	0.0	8.4	16.8	24.0
W/F-protein ratio (g/g) [b]	100/0	50/50	20/80	0/100
Lysine amino acid (mg/g protein) [a]				
LT-dried pasta	20.5 ± 0.6	38.6 ± 0.2	55.0 ± 0.5	65.1 ± 0.3
VHT-dried pasta	20.3 ± 1.8	33.4 ± 1.1	52.4 ± 3.0	60.3 ± 1.3
Cysteine amino acid (mg/g protein) [a]				
LT-dried pasta	17.2 ± 0.1	14.8 ± 0.6	10.4 ± 0.5	9.6 ± 0.7
VHT-dried pasta	17.4 ± 0.2	15.4 ± 0.3	10.4 ± 0.4	8.8 ± 0.3

[a] Analyses were performed in duplicate.
[b] Results obtained by calculation according to the ratio of raw materials and their protein composition.