Journal of Food Composition and Analysis 47 (2016) 8–15

Contents lists available at ScienceDirect

Journal of Food Composition and Analysis

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

Original research article

Nutrient composition and *in vitro* digestibility of fresh pasta enriched with *Vicia faba*

Karima Tazrart[a,b,c], Carmen Lamacchia[b], Farid Zaidi[c], Monika Haros[a,*]

[a] Institute of Agrochemistry and Food Technology (IATA-CSIC), Av. Agustín Escardino 7 Parque Científico, 46980 Paterna-Valencia, Spain
[b] Dipartimento di Scienze degli Alimenti, Università degli Studi di Foggia, Via Napoli, 25-71100 Foggia, Italy
[c] Département des Sciences Alimentaires, Faculté des Sciences de la Nature et de la Vie, Université de Bejaia, 06000 Bejaia, Algerie

ARTICLE INFO

Article history:
Received 10 June 2015
Received in revised form 8 December 2015
Accepted 28 December 2015
Available online 12 January 2016

Chemical compounds studied in this article:
Myo-inositol hexakisphosphate (PubChem CID: 890)

Keywords:
Fresh pasta
Broad-bean flour
Food composition
Food analysis
Cooking properties
In vitro digestibility
Mineral availability
Food fortification

ABSTRACT

Nutritionally enriched fresh pasta was prepared from semolina fortified with *Vicia faba* flour. Three addition levels were tested (10, 30 and 50%) and plain pasta (100% semolina) was used as a control. Enriched pasta showed lower cooking time, and higher dry matter loss, but with a similar water uptake. The shape of the pasta was not significantly affected by the cooking process. Color parameters indicated comparable brightness between samples and higher redness values for enriched pasta. The incorporation of broad-bean flour resulted in a significant increase in protein levels (21% against 13.7% in 50% enriched pasta and the control, respectively), fiber, resistant starch (from 1.4% in the control to 2.5% in 50% pasta), ash and minerals (calcium, iron and zinc). The mineral dietary reference intake contributions were higher in fortified pasta, and the enrichment percentage of 30% was the highest level, allowing improved iron availability. *In vitro* percent protein digestibility increased proportionally with the broad-bean substitution level. The rate of starch hydrolysis was reduced upon broad-bean enrichment, resulting in lower glycemic index (GI) for enriched pasta (91.9, 83.4 and 71.3 in 10%, 30% and 50% pasta, respectively) compared to traditional pasta (95.9) and white bread (100).

1. Introduction

Pasta has been consumed in the Mediterranean countries for many centuries and takes the second place after bread in world consumption (Mariani-Constantini, 1988; Torres et al., 2007). However, in the last few decades the demands for wheat-based products with added value have been growing rapidly (Gandhi and Zhou, 2014). Pasta may represent an excellent model food vehicle for the addition of specific nutrients through incorporation of various products (eggs, milk powder, vegetables, fiber, legumes, and so on) in a targeted food product to enhance nutritional quality, improve health condition and reduce the risk of diseases (Miceli et al., 2015).

Broad beans (*Vicia faba*), belonging to the family of leguminosae, are largely consumed in the Middle East, North Africa and South America. They represent a source of energy, protein, folic acid, niacin, vitamin C, magnesium, potassium, iron and dietary fiber (Azasa et al., 2009; Gimenez et al., 2013). Legume proteins are known to contain high levels of lysine and threonine, two essential amino acids that are deficient in cereal proteins (Abdel-Aal and Hucl, 2002). Hence, they represent an adequate complement to cereal proteins.

Pasta is classified into two major classes: fresh and dried. There are more than 400 unique types of filled and non-filled pasta, all with different forms and shapes. Non-filled fresh pasta is a widespread and appreciated type of pasta in Italy. This category includes various kinds such as *fettuccine*,*tagliatelle*, *penne*, *maccheroni*, *fusilli*, *pappardelle*, *rigatoni*, *capellini*, *conchiglie*, *Cicatelli*, *etc*. (Zanini De Vita, 2009). Fresh pasta can be produced with either soft wheat (*Triticum aestivum*) or hard wheat (*Triticum durum*) (Miceli et al., 2015). Some of these pastas are commonly produced artisinally as *Cicatelli*, which is a typical southern Italian fresh pasta, made exclusively with durum semolina wheat and water, and having an elongated, hollow shape. Starch, an important part of a balanced diet, presents up to 70% of wheat semolina pasta.

* Corresponding author at: Institute of Agrochemistry and Food Technology (IATA-CSIC), Av. Agustín Escardino 7, Parque Científico, 46980 Paterna-Valencia, Spain. Fax: +34 96 363 63 01.
E-mail address: mharos@iata.csic.es (M. Haros).

http://dx.doi.org/10.1016/j.jfca.2015.12.007
0889-1575/

While highly refined grains have a high glycemic index (GI), pasta, due to its compact structure, is considered as a source of slowly released carbohydrates; therefore processing a low GI (Hager et al., 2013). Fresh pasta fortification with legumes has not received so much attention from the scientific community. Hence, it is interesting to focus on this topic and investigate and bring out more information about the ability to produce this kind of food and evaluate their nutritional quality, along with technological and sensory aspects.

The purpose of the present work was to substitute durum wheat semolina in fresh *Cicatelli* pasta production with broad-bean (*V. faba*) flour at different percentages (10, 30 and 50%) in order to assess quality attributes, cooking behavior, starch and protein digestibility and mineral availability.

2. Material and methods

2.1. Raw materials

Durum wheat semolina is the common type of wheat used for pasta production, and it was kindly supplied by Manfredonia Fattoria (Foggia, Italy). The broad beans were cultivated and harvested in Kabylia region (Feraoun, Bejaia, Algeria). The dehulled grains were ground with a traditional mill and then sieved to pass through a 500 μm mesh screen.

2.2. Pasta production

Pasta produced was of the *Cicatelli* type, on a pilot scale according to the specifications and procedure of the Manfredonia Fattoria. Formulations included durum wheat semolina mixed with water in the case of traditional pasta, and durum wheat semolina and *V. faba* flour with water in the case of composite pasta. Four types of pasta were produced: a control made of 100% durum wheat semolina and three fortified pastas with 10%, 30% and 50% of the semolina, respectively, was replaced with *V. faba* flour. Fresh pasta was made on a moving belt by a robot that simulates the work of the human hand forming the *Cicatelli* shape. After that, a pasteurization treatment was performed by conveying the pasta through a chamber where steam was circulated both over and under the product. This step was subsequently followed by transporting the pasta to another chamber, where the product was dried with hot air to a final moisture content of 30–32%. Pasteurization was applied on fresh pasta in order to eliminate mould spores and avoid the proliferation of spoilage micro-organisms. After pasteurization and packaging in vacuum packages, the *Cicatelli* were freeze-dried and the obtained powders stored at 4 ± 2 °C in polyethylene tubes.

2.3. Chemical composition

Freeze-dried raw pasta samples were analyzed for moisture (AOAC 1998 Official Method 925.09), starch (AOAC Official Method 996.11), proteins (Kjeldahl, AACC 46-13), lipids (AOAC 1998 Official Method 945-16) and ash (AACC 1999 Official Method 08-03.01). Measurements were done in triplicate. The resistant starch content in cooked pasta was determined by quadruplicate according to the AOAC Method 2002.02. Briefly, samples were incubated with an enzymatic solution of pancreatic α-amylase (10 mg/mL) containing amyloglucosidase (3 U/mL) for 16 h in a shaking water bath at 37 °C. After centrifugation, the non-digested material was solubilized in 2 mol/L KOH, and then hydrolyzed with amyloglucosidase (EC 3.2.1.3) into glucose. The free glucose was finally quantified using glucose oxidase/peroxidase and measured spectrophotometrically at 510 nm.

2.4. Determination of total, soluble and insoluble dietary fiber

Total, soluble and insoluble dietary fiber contents were determined using AOAC Method 991.43, based on an enzymatic and gravimetric method. Fresh pasta samples were heated and gelatinized with heat stable α-amylase and then enzymatically digested with protease and amyloglucosidase to remove proteins and starch present in the sample. Ethanol was added to precipitate the soluble dietary fiber. The residues were then filtered and washed with ethanol and acetone. After drying, the residues were weighed. Half of the samples were analyzed for crude protein and the others were ashed. Analyses were performed in triplicate.

2.5. Determination of minerals

The total iron, calcium and zinc concentrations in uncooked and cooked fresh pasta were estimated using a Flame Atomic Absorption Spectrometer (Unicam 939 spectrometer, Burladingen, Germany). Previously, samples (0.5 g) were placed in a Teflon perfluoroalkoxy (PFA) vessels and treated with 4 mL HNO_3 14 M (Merck, Germany) and 1 mL of H_2O_2 30% (v/v) (Pancreac Quimica, Spain). The Teflon PFA vessels were irradiated at 800 W (15 min at 180 °C) in a microwave accelerated reaction system (MARS) from CEM (Vertex, Spain). At the end of the digestion program, the digests were placed in polypropylene tubes and made up to final volume with 5% HCl. Measurements were done in triplicate.

2.6. Determination of phytate

Phytate content of fresh pasta was measured in triplicate using a commercially available kit (K-Phyt 07/11 Megazyme, Ireland 2011). As per the manufacturer's instructions, phytates were extracted from 1 g of sample using 10 mL of HCl and then subjected to a dephosphorylation step with phytase and alkaline phosphatase. The total phosphate realized was measured using a colourimetric method using a color reagent of ammonium molybdate and ascorbic acid. The amount of molybdenum blue formed is proportional to the amount of inorganic phosphate present in the sample and was measured by the increase in the absorbance at 655 nm. Total phosphates was quantified as phosphorous from a calibration curve generated using phosphorus standard solutions using a spectrophotometer (Spectronic Unicam, Helios gamma, Birmingham, UK).

2.7. In vitro *starch digestion and glycemic index*

In vitro starch digestion and GI evaluation were estimated following the method described by Goñi et al. (1997). Briefly, the digestion procedure included a cooked fresh pasta sample (100 mg) in 10 mL HCl–KCl buffer (pH 1.5) with 400 μL pepsin 0.1 g/mL (Sigma P7000) and constant stirring for 1 h in a water bath at 40 °C. The volume was adjusted to 20 mL with Tris-Maleate buffer (pH 6.9). Then, 10 mL of a solution containing α-amylase (Sigma A6255), equivalent to 48 IU of enzyme activity per gram of sample in Tris-Maleate buffer (pH 6.9) was added. The samples were incubated at 37 °C in a shaking water bath (Ultrasonic Raypa UCL-200, Barcelona, Spain). Aliquots of 1 mL each at 0, 20, 40, 60, 90, 120 and 180 min were obtained and incubated at 100 °C for 5 min to inactivate the enzyme. Each test was cooled at the end of the incubation time. After centrifugation ($10{,}000 \times g$ at 4 °C) 500 μL of each supernatant was taken to a volume of 2 mL with sodium acetate buffer (pH 4.75). Then, 60 μL amyloglucosidase, 82 mg/mL, equivalent to 330 units (Sigma 10115) were added and incubated at 60 °C for 45 min with constant stirring. Subsequently, released glucose was determined in quadruplicate spectrophotometrically according