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Effect of water and gluten on physico-chemical properties and stability of ready to eat shelf-stable pasta

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ABSTRACT

A multi-analytical and multi-dimensional approach was used to investigate the effect of moisture and gluten on physico-chemical properties of shelf-stable ready to eat (RTE) pasta.

Moisture and frozen water contents were not affected by formulation nor storage time. Hardness and retrograded amylopectin significantly increased during storage in all samples, more markedly in pasta with the lowest moisture content. Higher amounts of water and gluten reduced pasta hardening and contributed to control RTE pasta quality. ^{1}H FID became steeper in all samples during storage, but no effect of high moisture and gluten levels was observed on the mobility of these protons. Three proton T_2 populations were observed (population C, population D and population E). Population C and D were not resolved during all storage. ^{1}H T_2 relaxation time of the most abundant population (population E) shifted to shorter times and the amount of protons increased during storage, more importantly in the samples with lower moisture and gluten content.

1. Introduction

Ready to eat (RTE) meals are becoming popular among consumers due to their convenience and the changes of eating habits. This trend is reflected by their significant market share (~10%) in recent years. Among RTE meals, pasta meals are indeed the main category as they represent a very large market segment, especially in Asia, Latin America, Middle and North Africa.

Pasta industry is introducing RTE pasta meals in the retail market in different storage conditions, primarily frozen, refrigerated or shelf-stable products. RTE pasta meals are generally constituted by a pasta phase and a sauce phase that may be in contact during storage or mixed only at time of consumption. The physical contact (or lack of it) between pasta and sauce are expected to have a key role on the dynamic interaction among meal components and the evolution of product's quality during storage.

To the authors' best knowledge, only few scientific reports have focused on the characterization of RTE pasta meals. Some works focused the attention on the changes occurring in the pasta phase during storage. Olivera and Salvadori (2009), Olivera and Salvadori (2011) studied quality parameters of cooked tagliatelle during frozen storage (up to 12 months) and the effect of freezing on tagliatelle properties. They reported a decrease of moisture content during the first 4 months and of hardness (first 2 months), that then remained almost constant during the rest of storage, and concluded that freezing had a negative effect on pasta structure. Carini, Curti, Cassotta, Najm, and Vittadini (2014a) focused their work on shelf-stable RTE pasta during 2 months of storage and reported an increase in pasta hardness and retrograded amylopectin as well as an increased molecular rigidity as measured by ^{1}H NMR (increased ^{1}H FID steepness and decreased ^{1}H T_2 relaxation times).

Other works investigated physico-chemical changes on RTE pasta meals in presence of sauce. Olivera and Salvadori (2012) observed decreased pasta hardness and increased moisture content in refrigerated lasagna (pasta with sauce) over 8 days storage. Carini, Curti, Littardi, Luzzini, and Vittadini (2013) investigated water status in shelf-stable pasta meals with a tomato based sauce during 34 days of storage, and reported pasta softening and water migration between pasta and sauce phases detected only at a molecular level (^{1}H T_1 and T_2), while moisture content and water activity did not reveal a macroscopic water migration between the pasta and sauce phases. The properties of the sauce should, also

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be carefully considered when used in a multiphasic meal (e.g. pasta and sauce).

A recent paper (Carini, Curti, Mora, Luzzini, & Vittadini, 2014b) has focused the attention on the sauce phase evaluating the effect of different ingredients commonly used in industrial settings on the status of water in the systems indicating that, for example, sauce thickening induced by flour or gelatin addition corresponded to very different NMR molecular mobilities.

Water and water dynamics are indeed a key factor in defining RTE meals quality and stability and a good understanding of the relation of water status indicators with product's composition, quality and stability is still a big challenge for food technologists.

In this work the effect of moisture content and gluten addition into RTE shelf-stable pasta was evaluated, during storage, in terms of physico-chemical properties and water status.

2. Materials and methods

2.1. Ready to eat shelf stable pasta production

Dry pasta (penne shaped) was produced by a local pasta maker using a standard formulation (semolina and water, STD) and was cooked into boiling water (pasta/water ratio 1:10) to reach 56% moisture (g H_2O/100 g product, control sample, STD-56). Pilot plant trials were carried out to optimize the moisture content and gluten level to have a high quality product and the optimal conditions were defined as 59% moisture and 15%, semolina substitution, dry mass. Dry gluten enriched (15%) pasta was produced and cooked into boiling water to 59% moisture (g H_2O/100 g product, GLU-59). A standard formulation pasta sample was also cooked to 59% moisture (STD-59). About 60 g of cooked pastas were packed into multi-layer (polypropylene-PP, polyethylene terephthalate-PET, and polyamide-PA) pouches and sterilized in autoclave ($F_0 \geqslant 7$) to obtain ready to eat shelf-stable pasta (RTE pasta). RTE pasta pouches were then kept at 22.5 °C for 63 days, and analyzed within 24 h from production (day 0) and after 3, 7, 10, 21, 28, 35, 42, 49 and 63 days of storage.

STD-56 sample was beforehand characterized and the results are included in a previous study (Carini et al., 2014a) but they were also presented in this paper to better study the effect of water and gluten contents on physico-chemical properties of RTE pasta during storage.

2.2. Moisture content

Moisture content (MC, % g water/100 g product) of RTE pasta was determined by weight loss by drying in a forced-air oven (ISCO NSV 9035, ISCO, Milan, Italy) at 105 °C to constant weight. At least ten pasta pieces of each RTE pasta sample at each storage time were analyzed.

2.3. Texture

Pasta texture was measured using a TA.TX2 Texture Analyzer equipped with a 25 kg load cell (Stable Micro systems, Goldalming, UK). Single pasta pieces were cut with a flat blade (speed of 2 mm/s; trigger force 0.1 N). The maximum height of the cutting peak was taken as "hardness". A small peak before the major peak was also observed in some samples, indicating a significant breakage of the pasta piece along its main axes when touched by the cutting blade. This peak was taken as evidence of pasta "fracturability". 15 pasta pieces for each sample at each storage time were analyzed.

2.4. Thermal properties

Frozen water content and amylopectin melting were measured using a Differential Scanning Calorimeter (DSC Q100, TA Instruments, New Castle, DE, USA) calibrated with indium (T = 156.6 °C; H = 28.71 J/g) and mercury (T = −38.83 °C, H = 11.40 J/g). About 5–10 mg of RTE pasta were placed into hermetic stainless steel pans (Perkin Elmer, USA). Samples were heated from −80 °C to 100 °C at 5 °C/min. DSC thermograms were analyzed using an Universal Analysis Software, version 3.9A (TA Instruments, New Castle, DE).

Frozen water content (at the select experimental conditions; FW) was calculated from the endothermic peak around 0 °C (ice melting) using the following equation:

$$FW = \text{Enthalpy Ice Fusion} * \left(\frac{1}{\text{Latent Heat Ice Fusion}}\right) * \left(\frac{1}{MC}\right) * 100$$

where FW is frozen water (%, g frozen water/g water), ice fusion enthalpy (J/g product), latent heat of ice fusion is 334 J/g ice, and MC is moisture content (g water/1 g product).

The occurrence of an endothermic peak in the 50–80 °C range was taken as recrystallized amylopectin melting. Enthalpy of this

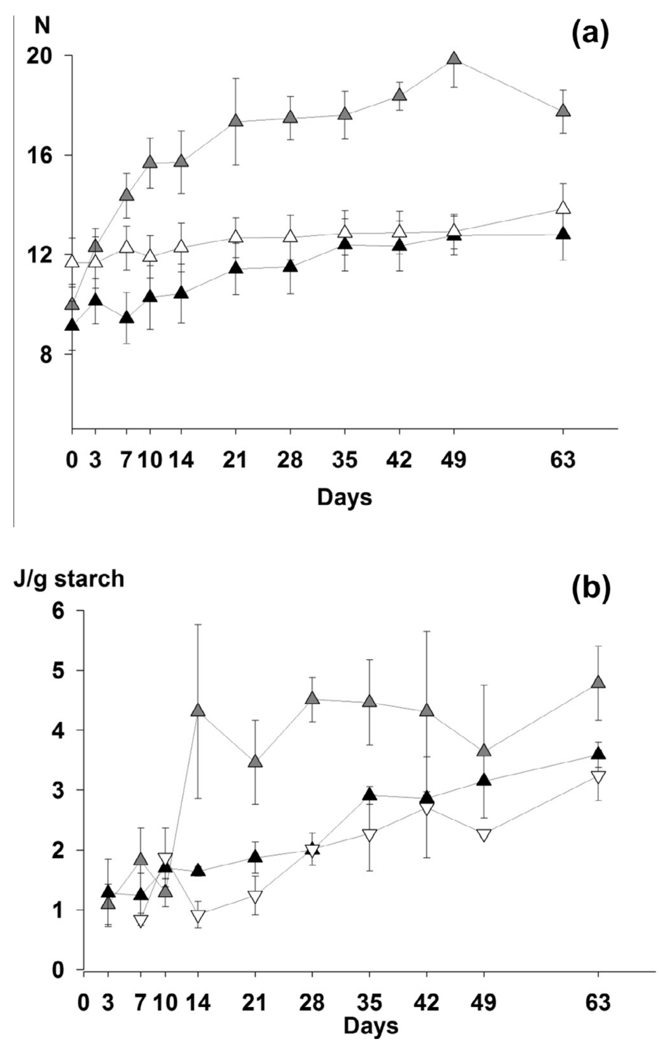

Fig. 1. (a) Hardness and (b) retrograded amylopectin of STD-56 (gray triangle), STD-59 (black triangle) and GLU-59 (white triangle) during storage.