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Consumer acceptance of UV-C treated liquid egg products and preparations with UV-C treated eggs

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ABSTRACT

The impact of short wave ultraviolet (UV-C) treatments on the organoleptic attributes of liquid egg products (raw or cooked: egg white, egg yolk, whole egg) and products containing UV-C treated liquid egg products as ingredient (mayonnaise, pudding, angel cake) is evaluated. Consumers were asked to distinguish between samples in triangle tests, and to express the degree of liking in acceptance tests. UV-C (5 to 30 min) or heat (following USDA ARS 74–48, 1969) resulted in comparable microbial losses for each product. UV-C treated liquid egg products could not be differentiated from the control below 25 min treatments. Processed egg fractions, cooked, or in egg preparations, could not be differentiated from the controls, either if heated or treated under UV-C during 30 min. Likely, overall scores for the sensory parameters evaluated indicated an acceptability of UV-C treated egg fractions or their preparations not significantly different from that of untreated and they were perceived as comparable to, or, in some cases, better than the thermally pasteurized eggs. No off-flavours due to UV-C treatments were reported. This study confirms no adverse effects on consumer acceptance of egg products processed by UV-C, with overall appearance or taste similar to the controls. Those findings are valuable to further consider UV-C treatment of eggs as a feasible alternative to heat.

1. Introduction

Eggs are a highly nutritive complete food, with an enormous relevance as a multifunctional food ingredient due to their technological properties. Liquid eggs, in addition to their nutritional value, contribute with some unique functional properties such as foaming, whipping, gelling, or emulsifying (Davis & Reeves, 2002), and are extensively used in the industrial production of bakery goods, confectionaries and ice cream (Stadelman, 1999). These properties of eggs can be easily impaired by heat, thus liquid egg pasteurization is conducted on a critical temperature-time regime where the coagulation of egg proteins is prevented (Mukhopadhyay Tomasula & Luchansky, 2009). The U.S. Department of Agriculture (USDA, 1969) demands that liquid egg whites are heated at 56.6 °C for not less than 3.5 min; same time and higher temperatures are required for whole eggs (60 °C), and egg yolks (61.1 °C).

Contrary to the limitations of thermal treatments for liquid egg products, UV-C radiation appears as an alternative and cost-effective non-thermal process in order to achieve microbiologically safe and shelf-stable products (Bintsis, Litopoulou-Tzanetaki, & Robinson, 2000; Geveke, 2008; Ngati, Smith, & Cayouette, 2006; Schmidt & Kauling, 2007). The use of ultraviolet light at germicidal wavelengths has been approved for food surfaces and clear fruit juices (US-FDA, 2002). The limitations in the germicide capacity of UV-C depend on intrinsic factors such as the chemical composition and the absorption coefficient of solids or large suspended particles, and of external factors such as the light intensity, or the temperature (Koutchma, Kellerb, Chirtelc, & Paris, 2004; Unluturk, Atilgan, Baysal, & Tari, 2008). Therefore to identify target food matrices it is first relevant to analyze specifically the effects of UV on microbial inactivation and food quality attributes. For this, experiments in batch or under laminar flows are providing reliable information on the microbial inactivation of microorganisms and the quality deterioration in liquid and solid foods (Bhat, Ameran, Voon, Karim, & Tze, 2011; Bolton & Linden, 2003; Noci et al., 2008).

Particularly in eggs, it is known that sensory and functional properties are sensitive to irradiation (Farkas, 1998). However, some works, such as Serrano, Murano, Shenoy, and Olson (1997), showed that relatively low doses, up to 1.5 kGy, would be sufficient to eliminate *Salmonella* from whole shell eggs and liquid whole eggs without significant adverse effects on the egg quality. Likely, de Souza and Fernandez (2011) found excellent perspectives for *Salmonella* inactivation in liquid egg products under UV-C radiation and concluded that low UV-C doses do not affect remarkably the investigated quality attributes (pH, colour, viscosity, lipid oxidation), being the higher doses milder than conventional pasteurizations for those parameters.

The instrumental analysis of physicochemical parameters shows therefore excellent perspectives for the UV-C treatment of liquid egg products, but those results do not guarantee consumer acceptance

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of the UV-C treated food. Consequently, this study focuses on a sensory evaluation of the impact of short wave ultraviolet treatments on key organoleptic attributes of liquid egg products and products containing UV-C treated liquid eggs as ingredient. For this analysis, consumers were asked to distinguish between samples in triangle tests, and to score the degree of liking of such products in acceptance tests.

2. Material and methods

2.1. Materials

Fresh eggs were purchased from Fazenda Rio Grande (Curitiba, Brazil). They were of yellow shell, and weighted between 55 and 61 g. After reception, eggs were inspected for shell integrity and damaged eggs were discarded. Just before experiments were carried out, the egg content (separately, egg whites and egg yolks) was removed under aseptic conditions, and collected in sterile containers. The pH of the samples was controlled before proceeding with the experiments and eggs were considered to be fresh when pH were around 7.2 ± 0.2 for egg white, and 6.2 ± 0.2 for the egg yolk. The chalaza was removed and the separated egg fractions were homogenized for one min using a vortex (QL901, Biomixer, Brazil), at 3000 rpm. To prepare the whole egg samples, 13.3 mL of egg yolk were mixed with 26.7 mL of egg white.

Ingredients required to prepare egg containing food products (angel cake, pudding and mayonnaise) were acquired in a local supermarket. Components requiring low temperatures were preserved in a refrigerator until experiments were carried out.

2.2. UV-C irradiation of egg samples

Following Bhat et al. (2011), UV radiation of samples at germicide wavelengths was conducted in batch in a UV bench scale chamber designed by UV-Consulting Peschl® España (Burjassot, Valencia, Spain) with dimensions $55 \times 35 \times 55$ cm. The chamber is provided with one low pressure mercury lamp with 7.3 W output and 436 mm length (Heraeus Noblelight GmbH, Hanau, Germany), with maximum peak radiation at 253.7 nm. Samples (12 mL volume; 0.2 cm height) placed in sterile polystyrene 60.3 cm^2 Petri dishes, were treated up to 30 min in 5 min intervals. Samples were situated at 10 cm from the lamp, and were continuously stirred during irradiation with magnetic stirrers at 400 rpm (AGM-5AQ, Arsec, Brazil). Under similar conditions, UV doses up to 4.2 Jcm^{-2} after 30 min were estimated by actinometry with the same lamp (Corrales, de Souza, Stahl, & Fernandez, in press).

Samples were irradiated at room temperature (20 °C) UV-samples were prepared in batches and stored under refrigeration until the necessary amount of product was treated; sensory evaluation of fresh liquid egg products was carried out immediately thereafter. Untreated and pasteurized samples were kept under the same conditions. For the cooked eggs and egg containing products, the egg preparation was the same as for the fresh product, and the cooking or product preparing was done immediately after the necessary amount of sample was collected.

2.3. Heat treatment

Intending to compare the UV treatment with treatments equivalent to conventional pasteurizations, one mL ampoules of whole egg, egg yolk or egg white were treated using a thermostatic bath (TBA23, SP Labor, Brazil) set to 56.6 °C, 60 °C and 61.1 °C for egg white, whole egg and egg yolk, respectively. The conditions for pasteurisation were chosen in conformity with the requirements of the USDA (USDA ARS 74–48, 1969). The holding time used for the three fractions was 3.5 min when the coldest point of the sample attained the pasteurization temperature.

2.4. Preparation of cooked eggs

Untreated, pasteurized or UV treated egg whites, whole eggs and egg yolks samples were homogenised in an electric mixer (Eletronic filter, Britânia, Brazil) during one minute and disposed in aluminium capsules (10 cm length, 4 cm diameter) until they were completely filled. The capsules were boiled in a water bath during 10 min and then allowed to cool down to room temperature. The cooked eggs were extracted from the capsules and cut into one cm thick slices.

2.5. Preparation of mayonnaise

Mayonnaise was prepared with the treated (UV-C or heat pasteurized) or untreated whole eggs using the following formula: egg (30%), sunflower oil (67%), salt (2%) and lemon juice (1%). The mixing of ingredients was performed using an electric mixer (Eletronic Filter, Britânia, Brazil). Oil was added slowly to the egg under continuous mixing to form the emulsion; after oil has been added, mixing continued for 5 min. This was followed by the addition of the lemon juice and salt, and mixing for additional 5 min. The mayonnaise was kept refrigerated at 10 °C until sensory analysis was carried out.

2.6. Preparation of puddings

Puddings containing untreated, pasteurized or UV treated whole eggs were prepared using the following formula: egg (20%), condensed milk (40%) and whole milk (40%). The mixing of ingredients was performed using an electric mixer (Eletronic filter, Britânia, Brazil) during 10 min. The mixture was transferred to a non-stick aluminium pan with central hole and baked in a boiling water bath during 1 h. The pudding was put in a refrigerator and was allowed to cool down in the mould until 10 °C were achieved.

2.7. Preparation of angel cakes

Angel food cake was prepared with the treated (UV or heat pasteurized) or untreated egg whites using the following formula: egg white (57.7%), sugar (24.2%), flour (13.4%), corn starch (3.4%), tartar cream (0.9%) and salt (0.4%). A planetary mixer (SX80, Arno, Brazil) was used to prepare the cakes. First, egg whites were mixed with the salt and tartar cream for 10 min while the other ingredients were hand mixed. The handmade mixture was slowly added to the mixer. The preparation was instrumentally mixed for 10 min prior to baking. The cake flour was sifted, combined, and mixed at low speed with the remaining sugar for at least 20 s. Baking took place at 175 °C for 45 min. Then cakes were cooled in an inverted position at room temperature.

2.8. Microbial evaluation of UV-C treated fresh liquid products

Total aerobic counts were evaluated on Plate Count Agar (PCA, Scharlau, Germany) after decimal dilutions in 0.1% peptone water using a pour plate technique. Total mesophilic microorganisms (MEC) were incubated at 30 °C for 48 h and enumerated. Total psychrotrophic microorganisms (PSC) were incubated at 22 °C for 120 h and enumerated (Gonzales et al., 2009).

2.9. Evaluation of sensory differences

Triangle tests were carried out in order to evaluate the differences between untreated, UV or pasteurized liquid egg products and products containing untreated, UV or pasteurized liquid egg products. For these experiments three samples were served to each member of the panel,