SENSORY CHARACTERISTICS OF OAT-BASED PASTA PRODUCTS

Denisa Eglantina Duta , Enuta Iorga, Nastasia Belc

National Institute of R&D for Food Bioresources IBA Bucharest, Romania, denisa.duta@bioresurse.ro

Abstract – The scope of this paper is to review the progress in the area of oat-based pasta production and sensory characteristics of the obtained products. Several studies were done to improve the nutritional value of pasta-as an important vector in many diets and to produce functional pasta enriched in bioactive compounds (including β-glucans from oat flours). The health conscious eating trend determined an increased demand for whole grain pasta and pasta made with fresh ingredients.

Keywords: sensory, oat, pasta, texture, cooking properties.

1. INTRODUCTION

A great emphasis is placed nowadays on the relationship between health, lifestyle and diet and the consumers are more aware of what they eat.

Pasta is highly convenient food product, consumed all over the world. Traditional pasta is made by using durum wheat semolina. The flour is mixed with water or eggs and formed into sheets or various shapes, then cooked by boiling or baking. It can be manufacture with flour from other cereals or grains also. Good quality pasta is defined as having high degree of firmness and elasticity. Proper evaluation of pasta cooking quality requires consideration of a number of factors including elasticity, firmness, surface stickiness, cooking tolerance, water absorption, and loss of solids to cooking water but also attributes related with the consumers' acceptability: colour, flavour (unusual flavour or off-flavour), palatability.

In order to enhance the nutritional value of pasta (increased protein, fiber, vitamins, minerals, antioxidants, polyphenols content etc.), studies were done on the possibility of adding functional ingredients into pasta: resistant starches and oat bran [1], pregelatinised cassava starch and bagasse flour, cassava starch and amaranth flour [2], buckwheat and durum wheat bran [3], oat flour [4], unripe banana flour [5], oat bran, psyllium fibre, Glucagel, inulin [6].

Oat (*Avena sativa*) is an important cereal crop used mainly as livestock feed but which received a great interest for human consumption due to a health claim granted by FDA and EFSA regarding the cholesterol-lowering effect of its soluble fibre component β-glucan. Oat is a good source of carbohydrates and quality protein with good amino acid balance. Oat contains high percentage of oat lipids especially unsaturated fatty acid, minerals, vitamins and phytochemicals. β-glucan usually comprises 2-8 % (dry weight) of the oat whole grain. Several factors affect the concentration of β-glucan including cultivar variation and the growing conditions (e.g. nitrogen level, temperature and rainfall). Oat β-glucan has been shown to lower/reduce blood cholesterol, which may reduce the risk of (coronary) heart disease. In order to bear the claim, foods should provide at least 3 g of oat β-glucan per day. This amount can reasonably be consumed as part of a balanced diet [7]. In Europe, the nutrition and health claims directive also provides a list of allowed nutrition claims, many of which also are relevant to cereal foods, such as "source of fibre" for products containing at least 3 g dietary fibers/100 g product, and "rich in fibre" for those containing 6 g dietary fibers/100 g product. Protein, vitamins and omega-3 and polyunsaturated fatty acids also are among those food components where nutrition claims may be used to show a high content [8]. Wholegrain oats also contain high amounts of unsaturated fatty acids, minerals, vitamins and phytochemicals. Protein found in oats is known to be nutritionally superior to that of wheat, due to higher lysine contents, a limiting aminoacid in cereals. Oat is consumed in different forms: flakes, porridge, bread, biscuits, sweet bars etc. Nowadays most of the diseases result from an inadequate feeding and some of them may be related to insufficient fiber intake.

As oats give a specific flavour and sometimes a bitter taste characteristic to the food products it is difficult to manufacture whole oat

bakery products. In order to increase the fiber or protein content, oat derivatives (β-glucan, bran) are incorporated in foods like bread, cakes, cookies, soups, yoghurts etc. Cereal, baked products and pasta as most consumed foods are used as vectors to increase the amount of ingested fibers or proteins.

The safety of oats in individuals with celiac disease has been extensively investigated. The clinical studies done over 5 years showed that consumption of pure, uncontaminated oats is safe up to 50–70 g/day by adults and 20 to 25 g/day for children. These results have increased the possibility of adding oats to a gluten-free diet and to diversify the coeliacs' diet [9].

All the changes in pasta composition by adding different ingredients have impact on the sensorial characteristics of the new developed product. Consumers often don't like these products because of many organoleptic and textural reasons such as colour, odour, cohesiveness, hardness, etc.

2. SCOPE AND APPROACH

This paper reviews progress in the area of using oat in pasta production, the methods used for sensory evaluation and the most important sensory attributes considered.

The search strategy for the present review sought recent published scientific work in English language associated with oats' potential as functional ingredient in pasta. The search was conducted on the online databases Science Direct, SpringerLink, Taylor&Francis and Wiley looking for references dating from 2008 onwards, using the terms "oat based pasta". A further search was conducted of the terms "sensory evaluation of oat based pasta", dating from 2008, in order to further narrow the subject of the present review.

3. KEY FINDINGS

Sensory evaluations are often used in research as well in the food industry to evaluate sensory characteristics and human response to food products. Sensory evaluation is a scientific method where the five senses (sight, smell, touch, taste and hearing) measure, analyze and interpret responses to products. The 9-point hedonic scale, ranging from like extremely to dislike extremely, is widely used when assessing the degree of liking [10].

Pasta is considered a healthy food, being low in fat and sodium levels, high in carbohydrate and having good protein content. Traditional pasta is made by using durum wheat semolina. In order to enhance the protein content and the nutritional value of pasta, several studies were done on the possibility of including functional ingredients into pasta. Grains different from durum wheat have been used as partial or total substitutes in the production of particular kinds of "pasta" with healthy characteristics or for specific targets, such as people following a celiac diet. The amount of high protein flour (soybean, pea, lupine, bean, and chickpea) that can be added to or substituted for semolina represents a compromise between nutritional improvement of the pasta and achievement of satisfactory sensory and functional properties.

The typical structural changes in wholegrain pasta are related with increased surface roughness, less glossy, dark colour, chewier, sticky and harder texture [11].

Few studies were done on the effect of oat additions to pasta products for increasing the fiber content.

Spaghetti based on oat flour was manufactured using carboxymethylcellulose sodium salt (CMC) as structuring agents, and pregelatinized starch. Colour, homogeneity of the uncooked pasta and stickiness, bulkiness, firmness, flavour and taste of the cooked pasta at optimum cooking time were evaluated. A nine-point hedonic rating scale, where 1 corresponded to extremely unpleasant, 9 to extremely pleasant and 5 to satisfactory (acceptability threshold) was used. Cooked oat based spaghetti were scored unacceptable (i.e., score lower than 5) from the firmness and adhesiveness point of view. The flavour received a score higher than 5 (5.5-6.2.) [12].

Researches were done on obtaining pasta with addition of oat bran (up to 10% from wheat flour) and resistant starch. Continuous bipolar 7-point scale was used, where −7 represented low intensity and 7 represented high intensity in a particular attribute. Control sample was located in position 0 in scale. The textural characteristics: firmness -the force required to cut through the spaghetti using the front teeth and chewiness- the length of time required to masticate the spaghetti

to a state of swallowing were evaluated by the panelists in the mouth. Elasticity- the extent to which a piece of spaghetti returns to its original length when stretched and surface stickiness- the extent to which two pieces of spaghetti stick together when separated were evaluated by the panelists by manipulating by hands. Overall acceptability of each sample was rated using the scale: 1 = dislike extremely to 9 = like extremely. Products were considered acceptable if their mean scores for overall acceptability were above 5 (neither like nor dislike). The sample based on oat had the lowest values in firmness, chewiness, elasticity and overall acceptability and the highest values in surface stickiness. In order to obtain acceptable oat-based pasta, it is recommended to use a percent for addition of oat bran of 5 % [13].

Studies were done to produce gluten-free pasta based on oat flour, egg white powder and emulsifier and the pasta quality parameters (firmness, elasticity, cooking loss, stickiness) were compared with pasta from wheat [14, 15]. Sensory analysis (aroma profile and overall liking) was carried out by a training panel. Aroma profile was evaluated by the assessors by sniffing the fresh cooked pasta. The odour attributes considered were: buttery, cooked potato-like, fatty, putrid, popcorn-like. The odour attributes intensities were scored on a scale from 0 (not detectable) to 3 (high intensity). The taste attributes considered were: sweet, salty, sour, bitter and umami. The taste attributes intensities were scored on a scale from 0 (not detectable) to 10 (high intensity). Other sensory textural properties were evaluated: juiciness, firmness and stickiness of the samples.The on a nine-point-scale from 1 (dislike very much) over 5 (neither like nor dislike) to 9 (like very much). Even the overall liking score was lower, the characteristics of oat pasta were close to the wheat pasta especially the textural attributes [16, 17]. In order to properly evaluate the odours, the assessors must be trained using aqueous odorant solutions in defined concentrations [18]. The odorant solutions have to be chosen to reflect the evaluated odour attribute:

- buttery: butane-2,3-dione
- cooked potato-like: 3-(methylthio-) propanal
- fatty: (E,E)-deca-2,4-dienal
- putrid: sodium sulphide
- popcorn-like: 2-acetyl-1-pyrroline.

Spaghetti was obtained from blends of soft wheat and oat flour and the cooking quality and textural attributes were analysed. Soft wheat flour was replaced with oat flour up to 45%. The results showed that pasta enriched with oat flour had a higher optimum cooking time and a reduced firmness. The samples with only 15% oat flour had similar characteristics with the samples from wheat [19]. These data are correlated with previous published studies [20], which observed a prolongation of optimum cooking time with increasing of oat flour level in noodle samples.

Spaghetti was processed from mixtures of durum wheat flour and soya flour or oat flour (10% w/w) and xanthan gum and the physicochemical and cooking properties were evaluated. Oat flour increased cooked weight and cooking losses and reduced the cooked firmness [21].

The effect of the addition of high-fiber oat powder and the drying conditions on the hydration properties and colour of pasta based on durum wheat was evaluated and the results showed a high impact. Short cut pasta was obtained by replacing semolina with high-fiber oat powder up to 20%. The most important pasta properties were determined: optimal cooking time, swelling index, water uptake, cooking loss and colour. The fortification of semolina with high-fiber oat powder decreased the optimal cooking time (OCT) from 6.5 min to 6.1 min in sample with 20 g/100 g of semolina replacement significantly increased the swelling index. The highest water uptake was observed in samples containing 12 g/100 g of non-gluten additive. Incorporation of fiber ingredients into durum wheat pasta increased water hydration values in samples up to 12 g/100 g of flour substitution. In samples with 16 and 20 g/100 g of semolina replacement a decrease of water uptake was observed what may be caused by the physical disruption of the starch-protein matrix by the presence of oat fiber powder. Cooking loss was lower in samples with dietary fiber addition than in control sample. Fortification of pasta with high-fiber oat powder significantly decreased brightness of dried pasta. Compared with convection air-drying, vacuum-drying allowed achieving brighter pasta colour and favourable hydration properties [22].

Noodle were prepared by wheat flour, salt, pasteurised liquid egg, sodium stearoyl-2-

lactylate and water. Oat flour was used to replace wheat flour in the formulation at the levels of 10, 20, 30, and 40%. The cooked noodles weresensory evaluated taking into account the attributes: surface properties (wetness, slipperiness, and micro roughness), chewing properties (hardness, cohesiveness, and sensation of starch between teeth after each chew), mouthfeel after chewing (chalkiness and stickiness), taste, and overall acceptability using a 9-point hedonic scale with 9-like extremely, 5-neither like or dislike, 4-dislike slightly, and 1-dislike extremely. As the addition of oatmeal increased, the sensory characteristics of pasta deteriorated. The sample with 10% oat flour received the highest sensory scores [23].

Researches were published on the manufacturing of spaghetti based on quinoa, oat, chickpea, broad bean, maize and soy flours. Dough rheological properties andthe sensory attributes were evaluated. The samples were analysed with a panel of 10 trained tasters: to estimate the optimal cooking time, to indicate color, resistance to break and overall acceptability of the dry spaghetti, as well as bulkiness, adhesiveness, taste and overall acceptability of the cooked spaghetti. A 9-point hedonic rating scale, where 1 corresponded to extremely unpleasant, 9 to extremely pleasant and 5 to satisfactory, was used. The sensorial properties as determined by the trained panelists are listed in Table 4 for each of the four experimental steps. The overall acceptability did not differ significantly among the samples and it was scored around the acceptability threshold (i.e., 5). In particular, the dry pasta was scored under the acceptability threshold (i.e., score lower than 5) from the color and resistance to break point of view, with the exception for the sample obtained from quinoa flour and pregelatinised oat starch that showed an acceptable resistance to break value. The cooked pasta was scored under the acceptability threshold for the taste, with only one exception for the samples obtained from quinoa starch, oat flour and pregelatinized oat flour, with the lowest content of quinoa flour. Moreover, results suggest that quinoa flour and pregelatinized oat improved the pasta quality from the bulkiness and adhesiveness point of view, whereas the oat flour made the pasta more adhesive [24].

4. CONCLUSIONS

Oat is one of the ingredients with health benefices and its consumption should be increased.

Oat flour involved significant modifications of pasta quality in comparison with samples based only wheat flour. These effects can be attributed to the formation of starch-lipid complex and to the weakness of gluten network caused by the presence of fibres from oat flour in high amount. The hydration and gelatinisation kinetics were modified also because of the changes in the internal structure.

The recent findings centred on oat based pasta show promising results. It is possible to improve the nutritional quality of pasta using oat flour without compromise its cooking quality. These results have potential application for developing new, diversified oat-based functional foods.

The pasta sector is facing a challenge in the form of increased societal focus on health issues such as obesity, diabetes and heart disease. Consumers are paying closer attention to their diets, driving manufacturers and retailers to address nutritional concerns and provide products with healthier attributes, such as whole grains, reduced sodium, and high fibre, but safety, tasty and convenient.

ACKNOWLEDGMENTS

This work was supported by a grant of the Romanian National Authority for Scientific Research and Innovation, CCCDI-UEFISCDI, project number 3/2015 (ERA-NET SUSFOOD OATPRO).

REFERENCES

[1] M.C. Bustos, G.T. Perez, A.E. Leon, ”Combination of resistant starches types II and IV with minimal amount of oat bran yields good quality, low glycaemic index pasta”, *International Journal of Food Science and Technology,* 48, pp. 309–315, 2013

[2] F.A. Fiorda, M.S. Soares Jr., F.A. da Silva, L.R.F. Souto, M.V.E. Grosmann, ”Amaranth flour, cassava starch and cassava bagasse in the production of gluten-free pasta: technological and sensory aspects”, *International Journal of Food Science & Technology*, 48, pp. 1977–1984, 2013

[3] S. Chillo, J. Laverse, P.M. Falcone, A. Protopapa, M.A. Del Nobile, ”Influence of the addition of buckwheat

flour and durum wheat bran on spaghetti quality", *Journal of Cereal Science*, 47, pp. 144–152, 2008

[4] T. De Pilli, A. Derossi, C. Severini, "Cooking quality characterisation of "spaghetti" based on soft wheat flour enriched with oat flour", *International Journal of Food Science and Technology,* 48,pp.2348–2355, 2013

[5] M. Ovando-Martinez, S. Sáyago-Ayerdi, E. Agama-Acevedo, I. Goñi, L.A. Bello-Pérez, "Unripe banana flour as an ingredient to increase the undigetible carbohydrates of pasta", *Food Chemistry*, 113, pp. 121–126, 2009

[6] M. Foschia, D.Peressini, A. Sensidoni, M.A Brennan, C.S.Brennan, "How combinations of dietary fibres can affect physicochemical characteristics of pasta", *LWT - Food Science and Technology,* 61(1):pp.41-45, 2015

[7] EFSA Scientific opinion on the substantiation of health claims related to beta-glucans from oats and barley and maintenance of normal blood LDL-cholesterol concentrations (ID 1236, 1299), increase in satiety leading to a reduction in energy intake (ID 851, 852), reduction of post-prandial glycaemic responses (ID 821, 824), and "digestive function" (ID 850) pursuant to Article 13(1) of Regulation (EC) No 1924/2006, *EFSA Journal*, 9 (6), p. 2207, 2011

[8] K. Poutanen, N. Sozer, G. Della Valle, "How can technology help to deliver more of grain in cereal foods for a healthy diet?" *Journal of Cereal Science*, Volume 59, Issue 3, pages 327–336, May 2014

[9] M.S. Butt, M. Tahir-Nadeem, M.K.I. Khan, R. Shabir, M.S. Butt, "Oat: unique among cereals", *European Journal of Nutrition*,47:68–79, 2008

[10]H.T. Lawless and H.Heymann, Sensory Evaluation of Food, Principles and practices, Aspen Publisers, 1999

[11] R.L. Heinio, M.W.J. Noort, K. Katina, S.A. Alam, N. Sozer, H.L. de Kock, M. Hersleth, K. Poutanen., "Sensory characteristics of wholegrain and bran-rich cereal foods - a review", *Trends In Food Science&Technology* 47, pp.25-38, 2016

[12]S. Chillo, V. Civica, M. Iannetti, N. Suriano, M. Mastromatteo, M.A. Del Nobile, "Properties of quinoa and oat spaghetti loaded with carboxymethylcellulose sodium salt and pregelatinized starch as structuring agents", *Carbohydrate Polymers*, vol. 78, no. 4, pp. 932-937, November 2009

[13]M.C. Bustos, G.T. Perez, A.E. León, "Sensory and nutritional attributes of fibre-enriched pasta" *LWT - Food Science and Technology,* vol. 44, no. 6, pp. 1429-1434, July 2011

[14] F. Wang, W. Huang, Y.Kim, R. Liu, M. Tilley, Effects of transglutaminase on the rheological and noodle-making characteristics of oat dough containing vital wheat gluten or egg albumin", *Journal of Cereal Science*, 54, pp. 53-59, February 2011

[15]A.S. Hager, F. Lauck, E. Zannini, E.K. Arendt, "Development of gluten-free fresh egg pasta based on oat and teff flour", *European Food Research Technology,* vol. 235, no. 5, pp. 861-871, November 2012

[16] AS Hager, M. Czerny, J. Bez, E. Zannini, E.K Arendt, "Starch properties, *in vitro* digestibility and sensory evaluation of fresh egg pasta produced from oat, teff and wheat flour", *Journal of Cereal Science,* vol 58, issue 1, pp. 156–163, 2013

[17] A.S. Hager, A. Wolter, M. Czerny, J. Bez, E. Zannini, E.K. Arendt, M. Czerny, "Investigation of product quality, sensory profile and ultra-structure of breads made from a range of commercial gluten free flours compared to their wheat counterparts", *European Food Research and Technology*, 235 (2), pp. 333–344, 2012

[18]M. Czerny, M. Christlbauer, M. Christlbauer, A. Fischer, M. Granvogl, M. Hammer, C. Hartl, N. Moran-Hernandez, P. Schieberle, "Re-investigation on odour thresholds of key food aroma compounds and development of an aroma language based on odour qualities of defined aqueous odorant solutions", *European Food Research and Technology*, 228, pp. 265–273, 2008

[19] T. De Pilli, A. Derossi, C. Severini, "Cooking quality characterisation of 'spaghetti' based on soft wheat flour enriched with oat flour, *International Journal of Food Science and Technology*, 48, pp. 2348–2355, 2013

[20]M. Majzoobi, B. Layegh, A. Farahnaky, "Inclusion of Oat Flour in the Formulation of Regular Salted Dried Noodles and Its Effects on Dough and Noodle Properties", *Journal of Food Processing and Preservation,* 38, pp.48–58, 2014

[21]G.K. Sandhu, S. Simsek, F.A. Manthey, "Effect of xanthan gum on processing and cooking quality of nontraditional pasta", *International Journal of Food Science and Technology*, 50, pp. 1922-1932, 2015

[22]M. Piwińska', J. Wyrwisz, M. Kurek, A. Wierzbicka, "Hydration and physical properties of vacuum-dried durum wheat semolina pasta with high-fiber oat powder", *LWT - Food Science and Technology* vol.63, issue 1, pp. 647–653, September 2015

[23] E.Aydin, D. Gocmen, "Cooking quality and sensorial properties of noodle supplemented with oat flour", *Food Science and Biotechnology* 20(2): 507-511, 2011

[24] M. Mastromatteo, S. Chillo, V. Civica, M. Iannetti, N. Suriano, M.A. Del Nobile, "A Multistep Optimization Approach For The Production Of Healthful Pasta Based On Nonconventional Flours", *Journal of Food Process Engineering*, volume 35, issue 4, pp. 601–621, August 2012.