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Finely comminuted frankfurters fortified with potato juice – Quality and structure

Przemysław Łukasz Kowalczewski [a,*], Grażyna Lewandowicz [a], Mirosława Krzywdzińska-Bartkowiak [b], Michał Piątek [b], Hanna Maria Baranowska [c], Wojciech Białas [a], Magdalena Jeziorna [a], Piotr Kubiak [a]

[a] Department of Biotechnology and Food Microbiology, Poznań University of Life Sciences, Poznań, Poland
[b] Institute of Meat Technology, Poznań University of Life Sciences, Poznań, Poland
[c] Department of Physics, Poznań University of Life Sciences, Poznań, Poland

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ABSTRACT

An attempt to design a sensorially attractive product addressed to consumers with Inflammatory Bowel Disease was made. Potato juice, in fresh and spray-dried forms, was chosen as bioactive agent, and the quality of finely comminuted frankfurter sausages produced with its addition was evaluated. The obtained products were analyzed for their proximate composition, textural properties, microstructure and water dynamics.

The results indicate that sausages produced with potato juice addition find satisfactory consumer acceptance and do not differ significantly in terms of protein, fat, salt and water content. Nonetheless, the form in which the juice was applied significantly influenced texture, microstructure and water dynamics of the final product. While the results obtained with native potato juice addition indicate that it can simply be used in exchange of water in the recipe, the addition of spray-dried juice impacted free water content and fat emulsification enough to significantly change the texture of the ready frankfurters, better dispersion and smaller size of fat droplets were observed. This was accompanied by increased maximum shear force.

1. Introduction

Consumers' expectations of food in countries with high Human Development Index value have expanded from simple satisfaction of hunger to proper nutritional value, or even health-promotion. This tendency is associated with the dynamics of occurrence of diet-related diseases. Beside lifestyle diseases, such as diabetes, hypertension and obesity, diseases affecting the gastrointestinal (GI) tract should also be considered important, with cancer and Inflammatory Bowel Disease (IBD) among them (Tominaga et al., 2013). Chronic and recurrent inflammatory condition that accompanies both these disorders may lead to malnutrition or anaemia as a result of impaired absorption of nutrients from the gut (Massironi et al., 2013; Gomollón and Gisbert, 2009). As iron supplementation, used in anaemia treatment, often leads to irritation, and is thus ineffective (Gomollón and Gisbert, 2009), non-conventional countermeasures are sought after.

Meat is rich in iron in a form that is efficiently assimilated. Easily digested meat products enriched with natural substances proven to relieve the inflammatory condition could be helpful. Fortification of such products with plant-derived substrates has lately been gaining attention as a way to improve their nutritional value (Doménech-Asensi et al., 2013; Karabacak and Bozkurt, 2008; Valencia et al., 2008). It is applied alongside the already classic production of probiotic meat products (De Vuyst et al., 2008) or fortification with oils (Cáceres et al., 2008; Ayo et al., 2007).

Finely comminuted frankfurters are cooked smoked sausages of a homogeneous and smooth texture that results from using bowl cutter for preparation of the raw material (Eyiler and Oztan, 2011; Deda et al., 2007). The products are often formed as Vienna sausage (Hadorn et al., 2008). Its consistency and lack of bigger pieces of meat or fat makes it very attractive, especially to children or elderly people. Provided quality ingredients are used, a tasty and easily digestible product of high nutritional value can be obtained. All these features make finely comminuted frankfurters suitable for individuals with GI tract diseases.

Potato juice has been long present in the traditional European folk medicine as a cure for gastric ulcer, it has potential to be used as an inflammation revealing additive. The functional effectiveness

* Corresponding author at: Poznań University of Life Sciences, Department of Biotechnology and Food Microbiology, Wojska Polskiego Str. 28, 60-637 Poznań, Poland.
E-mail address: przemyslaw@kowalczewski.pl (P.Łukasz Kowalczewski).

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and safety of potato juice were verified at the turn of the 21st century. It activity was clinically confirmed (Vlachojannis et al., 2010; Chrubasik et al., 2006). Furthermore, *in vitro* tests proved its cyto- and genotoxic activity against cancer cells of GI tract. The mechanism responsible involves formation of reactive forms of oxygen and induction of DNA damage in the cells (Olejnik et al., 2011). Some of the difficulties in its application in therapy are biodiversity-related variation in composition and instability in its native form (Burlingame et al., 2009). Stabilization of potato juice is possible (e.g. spray-drying), and the product has been shown to retain its antiproliferative activity against cancer cells even after exposure to elevated temperatures (Lewandowicz et al., 2012). Moreover, antioxidant potential of the juice can be improved by proper treatment such as enzymatic hydrolysis (Kowalczewski et al., 2012). It has also been suggested that the effectiveness of potato juice in gastric ulcer treatment are a result of its inhibitory activity against *Helicobacter pylori* (Bennet and Roberts, 2008). Finally, *in vitro* and *in vivo* studies have confirmed its anti-inflammatory influence, in both its native and thermally-treated forms (Lewandowicz et al., 2014).

Potato juice is a by-product generated periodically during starch production season, practically only in September and October. As already mentioned, it is an unstable material, thus if continuous production of supplemented frankfurters is to be considered, the juice has to undergo stabilization. As exposure to high temperatures does not exert negative effect on its biological activity, it is possible to utilize it in both fresh and spray-dried form (Dishisha et al., 2013; Kowalczewski and Bryła, 2012; Fang et al., 2011; Schieber et al., 2001). However, the form may affect the structure and consumer acceptance of the final product. The aim of this work was to evaluate the influence of potato juice, fresh and spray-dried, on the quality and structure of finely comminuted frankfurters supplemented with it.

2. Materials and methods

2.1. Potato juice

Freshly squeezed juice from potato variety "Agatha" and spray-dried powder obtained from it were used for fortification of frankfurters. Dried juice was obtained according to the procedure described in Polish Patent Application (Lewandowicz et al., 2014). A pilot scale dryer, Niro Atomizer 6.3 (Denmark), was employed. The following conditions were used: air temperature: 170 °C at the inlet to the drying chamber, 95 °C at the outlet, juice flow rate of 12 l/h. The dry mass of the powder was 90 ± 0.5%.

2.2. Frankfurters manufacturing

The sausages were prepared using meat from turkey shank (without skin) and pork jowl. The raw materials used, as well as the formulation, complied with dietetic recommendations addressed to patients suffering from inflammatory bowel disease and were consulted with the Regional Branch of the Polish Association Supporting People with Inflammatory Bowel Disease. These are in accordance with the current clinical knowledge (MacDermott, 2007). Table 1 presents the detailed composition of the three tested product variants. Before processing the meet was cured with a curing solution containing 99.6% NaCl and 0.4% $NaNO_2$. So prepared meat was then ground using an automatic meat grinder equipped with a grinding plate of 3 mm hole diameter. Next, the ground turkey meat was mixed with water, ice, spices and potato juice (spray-dried or fresh), and comminuted using a bowl cutter until homogeneous mass was obtained. Finally, ground pork jowl was added to the mixture and the process was continued until homogeneity was reached once again. The final temperature of the filling was below 12 °C. Sausages were then formed by filling into natural casing of 26–28 mm diameter. After this the sausages were transferred to a smoking chamber and underwent the following treatment: drying at 35 °C for 30 min, smoking at 40 °C for 20 min, cooking until a temperature of 71 °C was reached in the geometrical centre of the sausage, cooling by spraying with cold water until temperature was below 20 °C. The sausages were then refrigerated for 24 h. In both tested cases, the amount of potato juice (fresh and spray-dried) was calculated in order to allow introduction of identical dry mass of the juice.

Table 1
Formulation of the products.

Ingredient (%)	Control	Sausage with fresh juice	Sausage with spray-dried juice
Turkey shank meat	48.73	48.73	48.16
Pork jowl	24.37	24.37	24.09
Water (ice)	24.37	14.62	24.09
Spice mix	0.78	0.78	0.77
Curing mix	1.75	1.75	1.73
Spray-dried potato juice powder	0.00	0.00	1.16
Fresh potato juice	0.00	9.75	0.00

2.3. Proximate analysis

Water content was determined according to PN-ISO 1442:2000, fat content – Soxhlet method according to PN-ISO 1444:2000, total nitrogen – Kjeldahl method according to PN-75/A-04018; ISO 1871:2009, salt – argentometric method (Mohr) according to PN-73/A-82112. The collected data has been shown as arithmetic means ± SD ($n = 9$).

2.4. Texture analysis (Warner–Bratzler shear test)

The texture was analysed using Warner–Bratzler shear test, often employed to test the tenderness of meat products (Rodas-González et al., 2009; Destefanis et al., 2008; Caine et al., 2003).

Before the texture assessment 15 cores of 50 mm length and 25.4 mm diameter were cut from each sample. Each core was placed horizontally on the instrument table and sheared once through the center using a Warner–Bratzler shear attachment (73° V-notch blade) connected to a Texture Analyzer TA.XT2i (Stable Microsystems, Godalming, UK). A 50.0 N compression load cell was used and the crosshead speed was 1.5 mm s^{-1}. The results recorded were shear force (N, the maximum force required to cut the sample) and the work of shear (N × s, the work done to move the blade). Measurements were averaged between cores in replicate, and values were compared using one-way analysis of variance (ANOVA).

Table 2
Proximate composition of analyzed frankfurters.

Parameter	Control	Fresh juice addition	Spray-dried juice addition
Free water (%)	63.2 ± 0.8[a]	63.3 ± 1.0[a]	62.7 ± 0.5[a]
Protein (%)	17.8 ± 0.6[a]	17.9 ± 0.3[a]	18.3 ± 0.4[a]
Fat (%)	13.1 ± 0.9[a]	13.2 ± 1.3[a]	12.6 ± 1.1[a]
Salt (%)	2.32 ± 0.26[a]	2.21 ± 0.35[a]	2.63 ± 0.34[a]

The means in the rows with different superscripts are significantly different ($P < 0.05$).

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