BIOACTIVE NATURAL POLYPHENOLS IN REFORMULATED MEAT PRODUCTS. EFFECTS ON QUALITY TRAITS.

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Abstract – Consumption of meat products has been challenged for their potential role in the onset of chronic diseases. In this study, a broad range of popular meat derivatives including dry and cooked sausages, and dry and cooked hams were reformulated and their processing techniques revised to enable the inclusion of polyphenol-rich plant extracts and a concurrent reduction or even elimination of added nitrites. The resulting meat products retained considerable amounts of the added polyphenols while exhibiting acceptable sensory properties and a regular shelf life behaviour. Adding natural red pigments was an aid in nitrite reduction, helping to limit the negative effects on colour. However, differences were found between the family of minced (cooked and dried sausages) and whole (cooked and dried hams) meats, with the latter exhibiting worse colour traits when lower nitrite levels were used in combination with plant extracts.

Key Words – Meat products, nitrite, plant extracts

I. INTRODUCTION

In the last decade, several studies have been focused on the potential health risks linked to meat preservatives such as nitrite and salt, and the possible relationship between processed meat and cancer [1]. Therefore, innovative meat products and technologies have been investigated in order to protect and even promote consumer's health. To achieve this objective, the potential role of biologically active polyphenols as meat ingredients has been suggested [2]. Plant-derived polyphenols such as flavonoids, flavones, anthocyanins, proved able to exert a chemomodulatory effect through a variety of physiological processes. Amongst them, the promotion of a chemoprotective activity against chronic diseases such as colon cancer has been postulated [3-4]. Many naturally occurring herbs, fruits and vegetables are packed with bioactive substances and a variety of commercially available plant extracts have been manufactured to deliver a broad range of stable polyphenols for use as

ingredients in foods, including meat products. From a technical point of view, incorporating polyphenol-based extracts or their crude sources in the meat matrix is a complex task, for their potentially adverse impacts on colour, texture, flavour and overall acceptability. Whether a powdered solid or an aqueous or oil extract, polyphenols can pose major problems in terms of compatibility, especially when they are intended for inclusion in whole muscles or large meat cuts such as hams or shoulders. The scope of this study was to investigate the effect of natural extract supplementation in six major meat products, with special emphasis on their quality and sensory traits. To this aim meat products were reformulated and processed using two possible levels of nitrites and compared to the standard production. The meat items were chosen to represent some of the most popular meat products available through Europe, i.e. cooked ham (brine injected, BI), cooked Bologna sausage, Northern- and Southern-style dry-fermented sausages, and boneless dry-cured ham (brine injected, BI and brine vacuum impregnated, BVI) [5].

II. MATERIALS AND METHODS

For each meat item, three batches were manufactured:
(1) Control, with a standard ingoing amount of preservative (sodium nitrite or a mix of sodium nitrite/sodium nitrate), (2) std-NO2, standard preservative and a blend of polyphenols, and (3) low-NO2, without nitrite (Southern-style sausage and dried ham BVI), or 75mg/Kg (dried ham BI) or 25mg/Kg (cooked ham, cooked Bologna and Northern-style dry sausages).
Natural red pigments, allowed by current regulations, were added in low-NO2, except in dried ham. The amounts of polyphenols, added in

each meat product by means of plant extracts, were identified in preliminary trials (Table 1).

Table 1. Added amounts of polyphenols in the meat products

	g/Kg of meat
Bologna sausages	2.5
Dry sausages (NS)	2.0
Dry sausages (SS)	2.0
	g/L of brine
Dried ham (BI) - 10% of injection	5.7
Cooked ham (BI)- 10% of injection	6.6
Dried ham (BVI) - ratio brine:meat (1:3)	33

Major chemical components, total polyphenol content, ascorbic acid and lipid oxidation index were assessed for all meat formulations (N.3 samples for each formulation). Moisture, fat, protein and ash were determined according to the Official Methods 950.46, 991.36, 981.10, and 920.153, respectively [6]. The concentration of total phenolic compounds in meat samples was determined by the Folin-Ciocalteu method, following the extraction procedure reported by Rituparna et al. [7]; results were expressed in g of gallic acid equivalents (GAE) per kg of meat sample. Ascorbic acid was evaluated according to the procedure reported by Valls et al. [8]; results were expressed as mg ascorbic acid per kg of meat product. Sensory qualities of meat products were assessed by a trained panel of 8 members, using a quantitative descriptive analysis method [9], to evaluate the effect of natural polyphenols supplementation on the final sensory traits of each meat item. Panelists independently evaluated color, odor, taste and overall acceptability of whole and sliced meat products, focusing on foreign flavor or taste possibly generated by plant extract supplementation. Each sensory attribute was scored on a non-structured 0-9 intensity scale, where 0 and 9 identify the lowest and the highest attribute intensity, respectively

Data were analyzed using the ANOVA procedure of SPSS package ver. 21; significant differences between the formulations for each meat item were investigated by the LSD procedure.

III. RESULTS AND DISCUSSION

The polyphenol concentrations in meat products supplemented with plant extracts are graphically reported in Fig. 1.

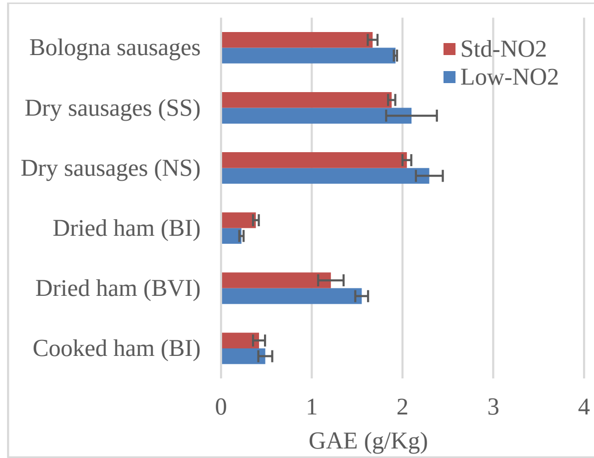

Figure 1. Concentration of total polyphenols in the meat products manufactured with natural polyphenols and two categories of sodium nitrite addition.

Values (in gallic acid equivalents) show that the available contents are dependent on the added plant extract amounts and the processing technique. In minced meats, thermal treatment results in a loss of the polyphenols compared with their fermented counterparts, where the plant substances are stable or even increased as a consequence of meat dehydration. As a tendency, all the minced meat items exhibit lower gallic acid equivalents in samples prepared with standard than with reduced nitrite addition. This is particularly the case with cooked Bologna sausages, whose polyphenol concentrations differ statistically, ($P<0.05$) according to the added nitrites. Data in Fig. 1 document a much lower uptake of plant substances in the family of whole meat products, whether cooked or dried. However, when dried hams are considered, those treated by vacuum impregnation are clearly shown to absorb more polyphenols than their conventionally brine-injected peers. Residual amounts of ascorbic acid in the finished meats are reported in Table 2. Values reflect the combined effect of the processing technique and added nitrites, with lower ascorbate losses in those items where nitrite depletion was greater. This observation is in agreement with the known nitrite reactivity, leading to rapid consumption of ascorbic acid when the two substances are allowed to interact. This was likely the case in both cooked meats, as well as in northern-style dry sausages and in BVI dried hams, where nitrite was possibly lost as result of the process, when added at the lower concentration level. Being quickly wasted, there was no enough nitrite left to react with ascorbic acid, which thus persisted at higher levels in low- than in standard nitrite added meats. There is no obvious reason why the same phenomenon did not occur in southern style sausage and in brine injected dried hams, whose residual ascorbic contents were greater in standard nitrite addition. It can be supposed that in these products the ascorbate was more intensively involved as an antioxidant, replacing the wasted nitrites.

Table 2. Content of ascorbic acid in meat products manufactured with a supplementation of natural polyphenols at two different amounts of sodium nitrite.

	Ascorbic acid [mg/kg]*	
	Std-NO2	Low-NO2
Bologna sausages	302±6	441±27
Dry sausages (NS)	365±28	425±20
Dry sausages (SS)	510±8	433±32
Dried ham (BI)	180±40	61±22
Dried ham (BVI)	38±2	431±71
Cooked ham (BI)	306±26	405±10

*Ascorbic acid differs ($p<0.01$) between std-NO2 and low-NO2.

Proximate composition data (Fig. 2) show that all products, excluding Bologna sausages, are a considerable source of protein, with dried meats ranging between 20-30%. Fat is relatively large in minced products, especially southern style dry sausages, whose 30% of fat essentially reflects the major shrinkage, hence concentration, resulting from dehydration. Nevertheless, the plant extract content is such that even a small portion will deliver a substantial amount of polyphenols with a relatively limited caloric intake.

As a rule, adding polyphenol-rich extracts affected selected sensory properties of reformulated meat products, including colour and flavour. This was the case with dried and cooked sausages and dried hams, where differences were found in the sensory attributes as assessed by the panelists.

As shown in Fig. 3-4, where the sensory scores are graphically reported, dry (northern) and Bologna sausages received higher ratings when the low-nitrite formulation was compared with its standard counterpart, an outcome likely due to the natural red pigments added in the former (low-NO2) recipe.

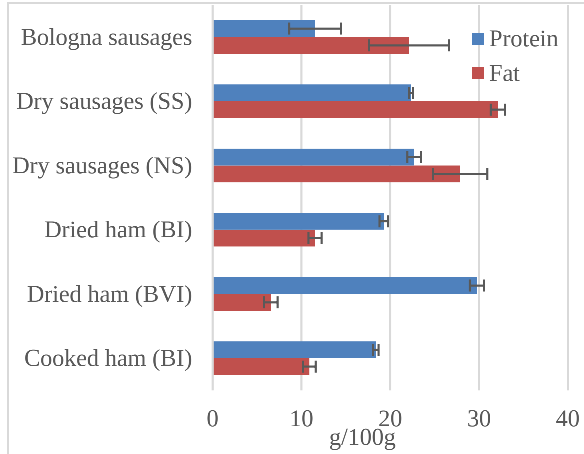

Figure 2. Protein and fat content of meat products.

In whole dried meats (hams), colour assessment (Fig. 5) resulted in greater scores being assigned to standard-nitrite samples, whereas hams made with lower nitrite were impaired by brown spots and grey discoloration, two major drawbacks probably tied to the combined effect of polyphenols and low nitrite. Herbal or foreign notes could be perceived by some panelists tasting the most heavily polyphenol-enriched samples. In spite of this, the attribute proving most influential in terms of acceptance was colour, the trait found the primary driver for overall liking of reformulated meat products in this study.

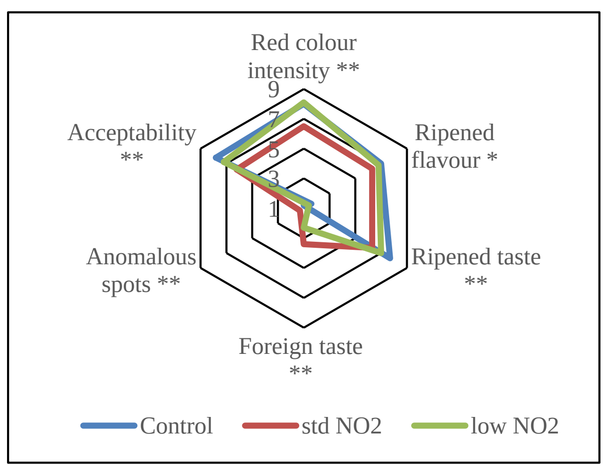

Figure 3. Sensory analysis of dry sausages (NS): mean values (n=3) for each sensory descriptor by process formulation. For each descriptor the relevant

significance is reported (** $p < 0.01$, * $p < 0.05$, n.s. = not significant)

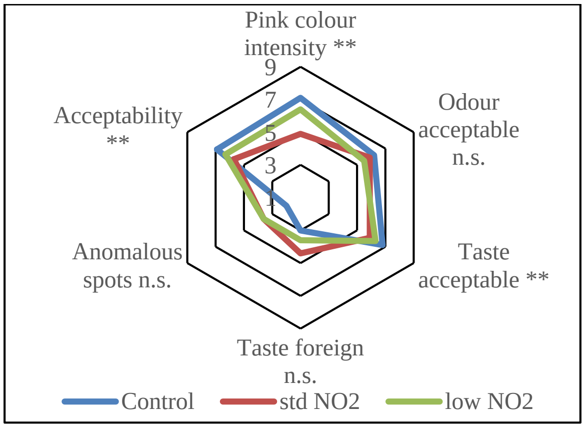

Figure 4. Sensory analysis of Bologna sausages: mean values (n=3) for each sensory descriptor by process formulation.

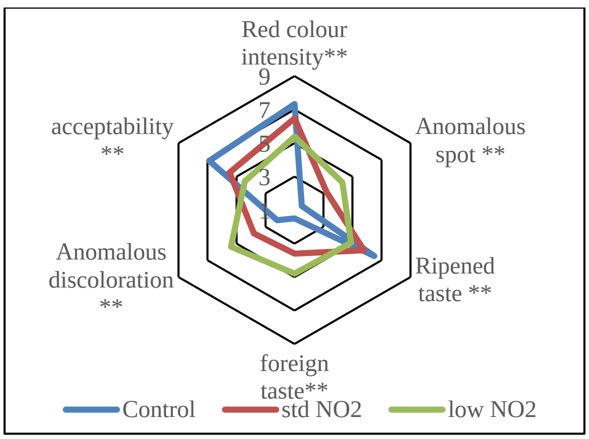

Figure 5. Sensory analysis of dried hams (BVI): mean values (n=3) for each sensory descriptor by process formulation.

IV. CONCLUSION

Incorporation of polyphenols as a means to improve the health profile of meat products can be successfully achieved by adapting existing technologies and reformulating current recipes to include adequate amounts of plant extracts. Depending on the meat item, and with the aid of natural red pigments, the inclusion of polyphenols can be paralleled by a significant reduction of added nitrites, with no or limited impact on colour and overall acceptability.

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