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REDUCTION OF NITRITES/NITRATES IN PROCESSED MEAT : HOW THIS MODULATES HEALTH RISKS?

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I. INTRODUCTION

Removal of nitrites and nitrates from processed meat appears to trade off food safety and quality for a lower potential cancer risk. These additives inhibit bacterial pathogens, most notably *Clostridium botulinum* and *Listeria monocytogenes*, extend product shelf life and oxidative stability [1]. But they also generate nitroso-compounds (nitrosyl hem, nitrosothiols and nitrosamines) potentially harmful [2].
Studies on alternatives approaches using plant-based substances such as polyphenols, vegetable extracts showed possibly antibacterial and antioxidant benefits but these works concern only one or even 2 processed meat products, whereas there are over 450 of them [3]. The reduction and withdrawal of nitrate additives are effective in limiting the formation of nitroso-compounds and therefore appear to be effective in limiting the population's exposure to these compounds, as recommended by ANSES [4]. However, in certain products, such as cooked products, this withdrawal or reduction to below 80 ppm would lead to a sharp increase in the formation of alkenals resulting from lipid peroxidation, and would therefore increase the population's exposure to these genotoxic compounds. The aim of this study is to determine, for each of the main product categories, the maximum reduction that can be achieved without increasing peroxidation.

II. MATERIALS AND METHODS

5 categories of processed meats were manufactured with different quantities of additives (NO_2 and NO_3) by ADIV (Clermont Ferrand): pork dry sausage, poultry ham, poultry sausage, “pâté en croute” (a harmonious blend of finely ground meat encased in a buttery pastry, sterilised country-style pâté. Table 1 summaries the different conditions. Residual nitrites and nitrates, nitrosylheme, nitrosothiols and nitrosamines (NOC) were assessed according to the methodology using chemiluminescence based on NO detection [5]. Moreover, lipid oxidation was measured through TBARS determination according to [4]. Statistical analyses (Anova) were performed using Jamovi 2.3.26.

Table 1: For pork dry sausages, 5 additive conditions were tested, for poultry ham 3 additive conditions and the effect of second cooking, for poultry sausage, the effect of cooking and storage with oxygen are evaluated; for “pâté en croute”, 3 additive conditions were tested; for sterilized country-style pâté 3 additive conditions were tested.

	NO_3/NO_2 ppm						Specific treatment
Pork dry sausage	0 / 0	110/90	120/120	160/0	200/0		
Poultry ham	0/0	0/80	0/120	*0/0*	*0/80*	*0/120*	*Second cooking*
Poultry sausage	0/0 raw	*0/0 raw*	0/0 cooked	*0/0 cooked*			Storage with 70% O_2 / 30% CO_2 or *under vacuum*
Paté en croute	0/0	0/90	0/120				
Country-style paté	0/0	0/40	0/120				

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III. RESULTS AND DISCUSSION

Concerning pork dry sausages, very little residual nitrite in the absence of additives in the recipe. A basal level of NO_3 was observed whatever the formulation highlighting the natural presence of nitrate in the muscle tissue. A negligible quantity of NOC was observed for almost all the formulations containing additives. For condition 120/120, the presence of nitrosylheme and nitrosothiol was slightly higher than for the other formulations, but still less than 1ppm and the lowest level of lipid oxidation (Table 2).
For the poultry sausage, the cooking and oxidation conditions were tested. With no added nitrites or nitrates, no residual nitrite or NOC was detected in any of the four formulations. Only NO_3 (basal level as for the sausage) was

quantified at a level varying between 4 and 6 ppm. Oxygen conditioning does not appear to have any impact on lipid oxidation.

For poultry hams, different NO_2 levels were tested as well as overcooking on the formation of NOCs. Residual nitrites were only quantified for formulations with NO_2, and NOCs were only detected for conditions with 120 ppm nitrites but below the quantification limits (0.1ppm). Overcooking poultry ham (6 minutes at 220°C in a dry heat oven) did not result in the formation of any additional NOCs, particularly nitrosamines. As the lipid content of the product is 2%, the quantity of lipid oxidation products is low.

For pâté en croute, only the addition of nitrite to the formulation was tested. As with poultry ham, residual nitrites were only observed when nitrite was voluntarily added (90 and 120 ppm) to the formulation. No NOCs were detected in these cooked meats. Although lipid oxidation is slightly higher in the preservative-free formulation, this value remains very low.

For sterilized pâté, only the addition of nitrite was tested. 0ppm condition added contained no residual nitrite. The 40 and 120 ppm conditions induce the formation of NOC. For 40 ppm, this value is too low to be quantified. the reduction to 40ppm (compared with 120ppm) reduces nitrosylheme formation by 34%. Lipid oxidation is logically higher for condition 0.

Table 2 : Residual nitrites and nitrates content, Nitrosylheme, nitrosothiol and nitrosamine in pork dry sausage expressed in ppm. Level of lipid oxidation (TBARS). ND : not detected

	Concentration nitrite, nitrate & NOC (ppm)					**Lipid oxidation** (Eq. MDA mg/kg)
(ppm) NO_3 /NO_2	Residual NO_3	Residual NO_2	FeNO Nitrosylheme	RSNO Nitrosothiol	RNNO Nitrosamine	TBARS
0 / 0	5.43 ± 2.04	0.34 ± 0.13	ND	ND	ND	0.34 ± 0.04
110/90	6.22 ± 0.96	2.38 ± 0.94	0.25 ± 0.11	0.22 ± 0.10	ND	0.33 ± 0.11
120/120	8.44 ± 1.67	2.47 ± 1.04	0.72 ± 0.25	0.72 ± 0.29	ND	0.19 ± 0.05
160/0	6.33 ± 1.54	2.20 ± 0.85	0.27 ± 0.13	0.22 ± 0.11	ND	0.29 ± 0.03
200/0	7.33± 2.20	2.18 ± 1.03	0.47 ± 0.35	0.38 ± 0.27	ND	0.29 ± 0.12

IV. CONCLUSION

The impact of the withdrawal or reduction of nitrate additives depending on the type of meat product and, similarly, the presence of nitrosamines, nitrites and residual nitrates, which also vary depending on the product, thus confirming the need to set specific reduction or withdrawal strategies for each product family.

In all the products tested above, there were no detectable nitrosamines. But other nitrosated compounds can be formed: in this case (sausage, sterilised paté), withdrawal is the best solution to block the formation of nitrosylheme and nitrosothiol. However, a reduction in the use of additives can be enough to bring about a very significant reduction in the formation of these two nitrosated compounds: for sausages, going from 120ppmNO_3/120ppmNO_2 to 110/90 divides the formation of Nitrosyleme by 3.

For sterilized country-style pâté, as far as the microbiological risk is controlled, additive could be withdrawn, thereby further limiting the public's exposure to NOCs.

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