TITLE: New formulations for healthier dry fermented sausages: a review.

AUTHORS: Muguerza, E., Gimeno, O., Ansorena, D., & Astiasarán, I. (*)

KEY WORDS: sodium, fat, meat products, hypertension, cardiovascular diseases.

Department of Food Science and Technology, University of Navarra, Faculty of Pharmacy, 31008-Pamplona, Spain.

Phone: 948-425600 (6405); fax: 948-425649.

(*)To whom correspondence should be addressed; E-mail: iastiasa@unav.es

Summary

An excessive intake of meat products, particularly dry fermented sausages, is not recommended from a healthy point of view, at least for some groups of population, due to their high level of sodium and animal fat. Many efforts of the meat industry are focussed on the development of new products with better nutritional properties than traditional ones. KCl, $CaCl_2$, and/or calcium ascorbate, among others, have been assayed as partial substitutes of NaCl, obtaining products with acceptable sensory quality, supplying smaller amounts of sodium and being sometimes a significant source of potassium or calcium. In relation to fat, last researches are focused on the use of different types of fibres and vegetable oils as partial substitutes of pork backfat. The use of fibres results in low-fat and low energetic products. The use of vegetable oils results in products with healthier fatty acid profiles. Aspects related with improving sensory properties and control of oxidation process should be taken into account in future researches.

Introduction

The nutritional value of meat products is mainly due to the energy supplied by these products, and also to their high biological value proteins, vitamins and minerals. However, from a healthy point of view, an excessive intake of these products can not be recommended especially for certain population groups, because of their significant sodium and fat content. Concerning fat supply, it is well known that the animal raw matters used in the elaboration of these products contain cholesterol and a higher proportion of saturated fatty acids (SFA) than polyunsaturated fatty acids (PUFA). Furthermore, most of the meat products are manufactured with NaCl, being important sources of sodium in the diet.

Health organizations all over the world have promoted the choice of a diet low in saturated fat and cholesterol and moderated in total fat, as a mean of preventing cardiovascular heart disease (AHA, 2000; USDA, 2000), which constitute one of the main cause of mortality in the world. Hypertension, which is one of the main risk factors of cardiovascular disease, is known to be correlated with an excessive sodium intake from the diet (Law, Frost & Wald, 1991; Truswell, 1994).

Those data show the need to develop low-salt and low-fat meat products which would be healthier for consumers. Several approaches have been carried out in this way in some types of meat products.

Reduction of NaCl and/or partial replacement by salts such as KCl, MgCl, LiCl, $CaCl_2$ and phosphates have been assayed at different percentages by many authors, analysing the effects on sensorial quality and microbiological stability in cooked products (Seperich & Ashoor, 1983; Kraft, 1983; Hand, Terrel & Smith, 1982b,c; Whiting & Jenkins, 1981; Arganosa & Marriot, 1990; Seman , Olson & Mandigo, 1980), cured ham (Leak, Kemp & Fox, 1987; Hand, Terrel & Smith, 1982a; Pinedo, Polkington & Foegeding, 1987; Keeton, 1984; Terrel, Ming, Jacobs, Smith & Carpenter, 1981; Terrel, 1983) and other processed meats (Miller, Davis, Seideman & Ramsey, 1986; Sofos, 1985).

Most of the researches about the development of low-fat meat products are related to cooked products using substitutes of fat such as carrageenans (Trius, Sebranek, Rust & Carr, 1994), gums (Mittal & Barbut, 1993), water (Ahmed, Miller, Lyon, Vaughters & Reagan, 1990; Sylvia, Claus, Marriot & Eigel, 1994; Small, Claus, Wang & Marriot, 1995) or proteins (Mc Mindes, 1991). Also vegetable oils have been used in cooked products (Marquez, Ahmed, West & Johnson, 1989; Park, Rhee, Keeton & Rhee, 1989; Park, Rhee, & Ziprin, 1990; Riendau, 1990; Liu, Huffman, & Egbert, 1991; Hammer, 1992; Bloukas & Paneras, 1993; Paneras & Bloukas, 1994; Bloukas, Paneras & Fournitzis, 1997b; Pappa, Bloukas & Arvanitoyannis, 2000) giving rise to products with more adequate fatty acid profiles and cholesterol levels than the traditional ones.

In relation to dry fermented sausages major difficulties are found to develop low-salt and low-fat products than in the previous cited products, because of the important functions that these two ingredients, salt and fat, have in the quality of those products. NaCl has an important influence on the final taste of dry fermented sausages and also plays an important role in the guaranty of the microbiological stability. Fat is necessary to an adequate development of those properties particularly related to texture, juiciness and flavour. For these reasons, most of the ingredients commercialised for the development of low-fat and low-salt meat products are applied to other products (cooked and processed meats) (Mc Auley & Mawson, 1994) not being too many researches in the bibliography refereed to dry fermented sausages.

This paper pretends to be a compilation of the research works focused particularly on the decrease of sodium and saturated fat in dry fermented sausages in order to show the future trends to obtain healthier products.

Reduction of sodium in dry fermented sausages

Gou, Guerrero, Gelabert & Arnau (1996) used potassium chloride, potassium lactate and glycine as sodium chloride substitutes in fermented sausages. These authors found important flavour defects with substitutions upper than 40% for the three substitutes. They also found changes in some parameters related to texture when NaCl was replaced by potassium lactate at levels higher than 30% or by glycine at levels higher than 50%. Table 1 shows some of the results obtained in different type of dry fermented products (fuet, Pasterma and chorizo) by different authors. Gelabert, Gou, Guerrero & Arnau (1995) found a decrease in the overall acceptability of fuet when potassium lactate, glycine and KCl were used at higher levels than 30%, 20% and 40%, respectively. Askar, El-Samahy, Shehata & Tawfik (1993) found differences in the overall acceptability, but these were not significant until NaCl had been replaced to a level of 50% (at a 1% level of significance) by KCl or K-lactate. Ibañez, Quintanilla, Astiasarán & Bello (1997) did not find significant differences between products manufactured with 3% of NaCl (control) and modified products manufactured with 1.5% NaCl and 1% KCl. The sodium reduction in these products was about 25%, in comparison with the traditional formulation, and the Na^+/K^+ ratio decreased from 4.38 to 0.87 (Ibañez, Quintallina, Cid, Astiasarán & Bello, 1996). In another work the same authors found that the nitrosation process and carbohydrate heterofermentative activity of the starter cultures was favoured in dry fermented sausages manufactured with a mixture containing 1.37% NaCl and 0.92% KCl in comparison with sausages manufactured with 2.73% NaCl (Ibañez et al., 1995).

Table 2 shows results obtained by Gimeno, Astiasarán & Bello (1998, 1999, 2001) in papers dealing with chorizo. Gimeno et al. (1998) when using a mixture of 1% NaCl, 0.55% KCl, 0.23% $MgCl_2$ and 0.46% $CaCl_2$ to replace the traditional 2.6% salt content in chorizo (16 mm particle size), found that the sodium content decreased from 1.88% in the control sausage to 0.91% in the modified product. However, sensorial acceptability was lower scored, mainly due to the lower salty taste. In chorizo de Pamplona, a traditional Spanish dry fermented sausage of 3mm particle size, a mixture of 1% NaCl, 0.55% KCl and 0.74% $CaCl_2$ was used, decreasing the sodium content from 1.35% in the control to 0.82% in the modified sausage (Gimeno et al., 1999). Significant increases of potassium and calcium (from 0.21 to 0.60% and from 154mg/100g to 319mg/100g, respectively) were observed in those products, which could be of interest from the nutritional point of view (although not bioavailability studies had been carried out). Concerning sensorial quality aspects, instrumental measures of texture (TPA analysis) and colour (CIEL*a*b*) showed some slight differences with regard to traditional products.

A significant reduction in the sodium content was also achieved through a partial substitution of NaCl by different percentages of calcium ascorbate, decreasing the sodium percentage from 1.98% in the control sausages to 1.07% in the modified products (Gimeno et al., 2001). In this experiment, calcium content increased from 130mg/100g in the control to 400mg/100g, which is the 50% of the RDA’s for this mineral. However, some small differences in the instrumental measures of colour and texture were again noticed.

It is important to point out that in every experiment described above no hygienic or safety problems related to the growth of undesirable micro-organism were detected.

The taste of these dry fermented sausages was generally described as less salty, which is sometimes positively evaluated by consumers.

Fat modifications in dry fermented sausages

In relation to the modification of the lipid fraction in dry fermented sausages one of the main strategies applied has been the reduction of the fat content and the simultaneous addition of non-lipid fat replacers or substitutes in order to minimize texture defects (Jimenez-Colmenero, Carballo & Cofrades, 2001). Mendoza, García, Casas & Selgas (2001) manufactured low-fat content dry fermented sausages with different percentages of inulin. Results showed that the addition of powdered inulin at a concentration of 11.5% gave better sensorial results than control low-fat products without any addition of inulin, but still statistically lower than control high-fat products. These products with 11.5% of inulin showed the lowest calorific value. Also Garcia, Domínguez, Gálvez, Casas & Selgas (2002) manufactured dry fermented sausages with 6 and 10% pork backfat with addition of cereal (wheat and oat) and fruit (peach, apple and orange) dietary fibres, at 1.5 and 3% concentration. These authors found that sensorial and textural properties of batches with 3% dietary fibre were the worst, due to their hardness and cohesiveness. The best results were obtained with sausages containing 10% pork backfat and 1.5% fruit fibre especially those with orange fibre. An appreciable decrease of the energetic value was also achieved in these products. Table 3 shows some of these results.

Recent studies pointed out the interest of a change in the dietary lipid profile of foodstuffs into a healthier pattern, instead of a reduction in the total dietary fat by using other substances. As a way to goal this objective, the latest studies try to modify the composition of the animal raw matter (pigs) through a change in the diet (CAST, 1991; Morgan, 1992; Cherian & Sim, 1995; Romans, Wulf, Johnson, Libal, & Costello, 1995; Myer, Lamkey, Walker, Brendemuhl & Combs, 1992; Mitsuharu, Yoshihiro, Keiichi, Yuuko & Hiroyuki, 1997, Cava et al., 1997; Irie & Sakimoto, 1992; Enser, Richardson, Wood, Gill & Sheard, 2000; Cava, Ruiz, Ventanas & Antequera, 1999; De la Hoz, López, Hierro, Ordoñez, & Cambero, 1996). Another possibility is the modification of the lipid fraction through changes in the formulation of meat products, being dry fermented sausages susceptible to these strategies. A partial substitution of pork backfat by olive oil was assayed in Greek dry fermented sausages (Bloukas, Paneras & Fournitzis, 1997a) and also in chorizo de Pamplona (Muguerza, Gimeno, Ansorena, Bloukas, & Astiasarán, 2001). In the last ones (chorizo de Pamplona) technologically and sensory acceptable products were developed, reaching a 25% substitution of pork backfat by olive oil pre-emulsified with soy protein. When a higher percentage of substitution was used drip fat was observed. These products showed increments in the MUFA and PUFA fractions, and reduction in the cholesterol content, improving consequently their nutritional quality.

One of the potential problems derived from these modifications could be an acceleration of the oxidative processes due to the increment in unsaturated fatty acids, particularly polyunsaturated ones, which are more prone to oxidation. However, in the previously cited papers no increments of hexanal (an aldehyde used as an oxidation index) and no rancidity notes were detected when substituting up to a 25% of pork backfat by the pre-emulsified olive oil. Negative effects in texture or colour instrumental parameters were neither observed.

Studying these modifications in Greek dry fermented sausages, Muguerza, Fista, Ansorena, Astiasarán & Bloukas (2002) concluded that a substitution of a 20% of pork backfat by pre-emulsified olive oil was possible in reduced and low fat dry fermented sausages. The obtained products showed 37% and 53% lower fat content than traditional sausages. The reduction in the fat level leaded to an increase in the weight loss, hardness and firmness of the modified sausages, which were also darker and with a higher red intensity colour (a* value) than control. However, the substitution of 20% of the pork backfat by pre-emulsified olive oil did not affect weight loss, obtaining lighter products and with a higher yellow intensity (b* value).

Some studies have also been carried out using soy oil as partial substitute of pork backfat. Table 4 shows the fatty acid modifications caused by olive and soy oils substitution, respectively. In both cases, the use of vegetable oils led to a reduction in cholesterol content of 12.92% and 5.65%, respectively. The total content of unsaturated fatty acids only increased in olive oil products. Soy products did not show this increment due to the decrease in MUFA. However, the MUFA+PUFA/SFA-stearic and PUFA/SFA-stearic ratios increased in both experiments, being this last ratio almost double in soy oil products (Muguerza, Ansorena, Gimeno & Astiasarán, 2002).

Conclusions

- Partial substitution of NaCl in dry fermented sausages by other salts as calcium ascorbate could imply interesting health benefits.
- Partial substitution of pork backfat by inulin and other dietary fibres seems to be a viable strategy to develop low-fat dry fermented sausages.
- The use of vegetable oils as partial substitutes of pork backfat is an interesting way to change the fatty acid profile of dry fermented sausages. Only a few works deal with the potential problem of oxidation of dry fermented sausages who present a higher degree of unsaturated fatty acids than traditional ones. It seems to be very interesting to conclude about the technological and commercial availability of these products.

Table 1. Overall acceptability of different cured fermented meat products developed through different researches in relation to sodium reduction

		Overall acceptability
Experiment in fuet (1)	10%-C K-lactate	-0.02
	20%-C K-lactate	-0.18
	30%-C K-lactate	-1.65*
	40%-C K-lactate	-1.55*
	10%-C Glycine	-0.54
	20%-C Glycine	-0.89*
	30%-C Glycine	-1.21*
	40%-C Glycine	-1.63*
	10%-C KCl	0.23
	20%-C KCl	0.15
	30%-C KCl	-0.07
	40%-C KCl	-0.78*
Experiment in Pasterma (2)		
	Control	41.1[a]
	70% NaCl+30% KCl	40.6[a]
	60% NaCl+40% KCl	39.6[a]
	50% NaCl+50% KCl	34.1[b]
	70% NaCl+30% K-lactate	39.8[a]
	60% NaCl+40% K-lactate	39.0[a]
	50% NaCl+50% K-lactate	32.2[b]
Experiment in chorizo (3)		
	Control	6.66[c]
	1.5% NaCl+1%KCl	6.17[c]

(1):Gelabert et al. (1995). Data showed correspond to the differences obtained in relation to the products considered as control. Level of significance: * $p<0.05$
(2): Askar et al. (1993). Data with the same superscripts did not show significant differences between them at level of significance of $p<0.05$.
(3): Ibañez et al. (1997). Data with the same superscripts did not show significant differences between them at level of significance of $p<0.05$.

Table 2. Content of Na^+, K^+ and Ca^{2+} of different dry fermented sausages.

	Chorizo		Chorizo de Pamplona			
	Control	**A(*)**	**Control**	**B(**)**	**Control**	**C(***)**
Na^+ (g/100g sausage)	1.88	0.91	1.35	0.82	1.98	1.07
K^+ (g/100g sausage)	-	-	0.21	0.60	-	-
Ca^{2+} (mg/100g sausage)	-	-	154	319	130	400

A (*) 1% NaCl, 0.55% KCl, 0.23% $MgCl_2$, 0.46% $CaCl_2$; **B (**)** Salts mixture: 1% NaCl, 0.55% KCl, 0.74% $CaCl_2$; **C (***)** 50 % of Calcium Ascorbate of the Recommended Dietary Allowance (RDAs)
Sources; Gimeno et al. (1998). Journal of Agricultural and Food Chemistry 46: 4372-4375; Gimeno et al. (1999). Journal of Agricultural and Food Chemistry 47: 873-877; Gimeno et al., (2001). Meat Science 57: 23-29.

Table 3. Results for % fat reduction, calorific value and acceptability in relation to the use of inulin, cereals and fruit fibres as texture modifiers in low fat dry fermented sausages.

		% Fat reduction	Calorific value (Kcal/100g)	Acceptability
Experiment with inulin (1)	Control high fat		392.2	7[a]
	Control low fat	48.5	305.7	5.9[b]
	R1 (7% inulin)	65.3	257.1	5.5[b]
	R2 (6%inulin)	55.9	271.0	5.4[b]
	R3 (11.5% inulin)	64.6	242.9	6.1[b]
	R4 (10% inulin)	60.1	251.5	5.4[b]
Experiment with dietary fibres (2)	Control 25% fat		435.9	6.48
	Control 6% fat	60	275.2	5.71[cd]
	Wheat 3%	65	281.9	4.04[d]
	Wheat 1.5%	61	300.6	6.10[c]
	Oat 3%	66	270.8	4.42[d]
	Oat 1.5%	68	264.6	6.12[c]
	Peach 3%	63	277	4.88[d]
	Peach 1.5%	57	290	6.08[c]
	Apple 1.5%	59	289.5	5.39[cd]
	Orange 1.5%	62	287.7	5.94[cd]
	Control 10% fat	62	287.9	5.99[c]
	Wheat 1.5%	61	292.3	5.09[c]
	Oat 1.5%	63	289	5.57[c]
	Peach 1.5%	59	277.5	5.93[c]
	Apple 1.5%	61	269.9	6.00[c]
	Orange 1.5%	57	278.9	6.33[c]

Experiment with inulin (1): Source Mendoza et al. (2001). Data with the same superscripts did not show significant differences between them at level of significance of $p<0.05$.
Experiment with dietary fibres (2): Source García et al. (2002). Data with the same superscripts did not show significant differences between them at level of significance of $p<0.05$.

Table 4. Cholesterol and other lipid related parameters obtained in dry fermented sausages in which a partial replacement of pork backfat was done with vegetable oils.

	Olive oil		Soy oil	
	Control	25% substitution	Control	25% substitution
Cholesterol (mg/g DFS)	94.24	82.06 (**)	92.96	87.71 (n.s.)
Σ SFA-stearic (g/100g product)	8.53	7.92	7.21	4.89
Σ MUFA (g/100g product)	14.07	16.26	12.82	9.75
Σ PUFA (g/100g product)	3.68	4.87	4.26	5.55
MUFA+PUFA/SFA-stearic	2.08	2.67	2.31	3.13
PUFA/SFA-stearic	0.43	0.61	0.58	1.13

DFS, dry fermented sausages; SFA, saturated fatty acids; MUFA, monounsaturated fatty acids; PUFA, polyunsaturated fatty acids.
[d]LS, level of significance: ns, not significant; **, $p < 0.01$.
Source: Muguerza et al. (2002). 48th ICoMST. Rome, 25-30 August, Vol 2, 1012-1013.

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