Cooked meat products enriched with different calcium salts

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Abstract— **Calcium is one of the most important minerals in the human diet but it is present in low quantities in meat and meat products. In this study calcium citrate-malate, lactate and gluconate have been added to cooked sausages in an attempt to determine whether they are useful for enriching these meat products. Different amount were added (20, 30 and 40% of the RDA). Calcium lactate and gluconate were adequate at concentrations of 30% while calcium citrate-malate gives good results until a 40% of the RDA.**

Keywords—**Calcium salts, cooked meat products, calcium enriched sausage**

I. INTRODUCTION

Calcium is one of the most important minerals in the human diet, it is necessary for both the structure and function of the body. It is essential for the growth and maintenance of the skeleton and teeth, where it ensures the structural integrity of mineralized tissue. Calcium also plays a diversity of other roles in the maintenance of cellular and secretory functions, contraction of skeletal muscle, fat mobilization, and blood coagulation; in addition, it acts as co-factor in a number of enzymatic reactions [1, 2]. Interest in dietary calcium has grown in recent years, because different studies have linked inadequate calcium intake to diseases such as osteoporosis, osteopenia and arterial hypertension, among others [3, 4].

Many people do not take in an adequate amount of calcium, either because it is lacking from their diet or because they fail to absorb it efficiently from their food. To ensure adequate intake, the U.S. Institute of Medicine [5] recommends a daily intake of 1000 mg for adults 19-50 years old, and the European Union [6] recommends 800 mg for all adults, irrespective of age.

While milk and dairy products remain the best sources of calcium, researchers and the food industry have focused on increasing intake of this mineral by designing and commercialising an extensive range of calcium-enriched products, ranging from dairy products to beverages and even cereals [7].

Meat and meat products are a very important part of the human diet because of their high protein content. However, they are considered a relatively minor source of calcium. Enriching them with calcium could be an effective way to increase their nutritional value.

Two main methods for enriching meat products with calcium have been described: direct addition of calcium salts, or their incorporation as a substitute for sodium chloride, either alone or in combination with bivalent cations [8]. Direct addition is the more frequently used option. According to Weaver [9], the calcium salt ideally should show good absorption and food compatibility, and it should be inexpensive and safe.

The main objective of the present work was to prepare calcium-enriched cooked meat products by direct addition of different calcium salts, i.e. citrate-malate (CCM), gluconate (CG) and lactate (CL), and then analyze their physico-chemical and sensory properties. It has been determined the optimal amount of calcium that would provide the best compromise between overall product quality and nutritional value. These three salts were selected because of their high bioavailability [10]. In addition, CG and CL have already been used to successfully prepare calcium-enriched dry fermented sausages [11].

II. MATERIALS AND METHODS

A. Sausage manufacture

Sausages were manufactured in duplicate according to a traditional formula for *mortadela*, a Spanish bologna-type cooked meat product, i.e. 55% pork meat, 30% back fat (pork), 10% ice and 5% of a

commercial mixture of spices and additives (Anvisa, Arganda del Rey, Spain). For each salt, three batches of sausage were prepared containing different amounts which were intended to provide 20, 30, and 40% of the recommended daily amount (RDA) of calcium (1000 mg). A fourth control batch of sausage without any salt was also prepared.

To prepare the sausage, meat and back fat were chopped in a cutter (Robot-Coupé, Mod 20 v, MS, USA). Then half of the spices, of the ice and half of the calcium salt were added and the chopping was continued for 2 more minutes. The remaining spices, ice and calcium salt were added to the batter which was mixed until the emulsion had formed completely. The temperature was maintained below 4ºC throughout this process.

The meat mixtures were stuffed in artificial plastic casings and introduced in a steam oven at 78 ºC until the temperature inside the sausages reached 72 ºC inside the sausages. After the cooking, they were cooled and kept to 4 ºC until their analysis.

B. Physico-chemical analysis

Sausage pH was determined using a Crison 2001 pH meter. Water holding capacity (WHC) was determined using the compression method [12]. Five samples were analysed for each batch.

C. Colour analysis

Colour was measured at room temperature on the surface of freshly cut slices with a thickness of 3 mm, using a Chroma Meter CR-400 colourimeter (Minolta Co., Osaka, Japan) and a D-65 illumination source. The colourimeter was calibrated with a rose tile (L* 44.88, a* 25.99, b* 6.67). The Space colour CIEL*a*b* was used to estimate colour properties. Fifteen measurements were made on each batch.

D. Texture analysis

Textural profile analysis (TPA) [13] was carried out using a Stable Micro System Mod. TA.XT 2i/25 texturometer.

From each batch, 8 slices were prepared with a height of 1 cm and a diameter of 2.5 cm. Samples were compressed twice to 50% of their original height. Hardness, springiness, cohesiveness and adhesiveness were determined.

E. Sensory analysis

Fifteen trained panelists performed the sensory analysis, working in individual booths under white fluorescent lights. Panelists were offered with two slices of each batch; the batches were assessed over several sessions, such that no more than three samples were analyzed in one day. Slices were approximately 2 mm thick. Unsalted crackers and room temperature water were provided to clean the palate between samples.

A hedonic test was performed using non-structured, 10-point scales (0 = extremely dislike, 10 = extremely like) in which the assessors evaluated different attributes: odour, colour, texture, taste and overall acceptability.

F. Statistical analysis

Statistical analyses were carried out using Stargraphics 5.0 Plus (Statistical Graphics Corporation, Herndon, VA, USA). Two-way ANOVA was used to determine whether the type and amount of calcium salt produced significant differences in the physico-chemical or sensory properties of the sausages. Principal component analysis (PCA) was carried out on the TPA results, and the outcomes were presented as bi-plots of batches and attributes.

III. RESULTS

A. Physico-chemical analysis

Table 1 shows the pH and WHC results. The values shown are the means of five measurements made of each batch; for each calcium salt, the three different amounts tested gave similar results ($p<0.05$). Differences in pH were found between the control and CG and CL batches; the CG pH was slightly lower than the control, while the CL pH was slightly higher. WHC differed significantly between the control and each of the other three batches.

Table 1. Effect of the type of calcium salt on the pH and water holding capacity (WHC) of sausages.

Batch	pH	Water Holding Capacity
Control	5.90±0.11[b]	43.26±2.16[c]
CCM	5.78±0.02[b]	52.46±7.66[a]
CG	5.62±0.09[c]	54.68±1.50[a]
CL	6.14±0.03[a]	47.57±3.44[b]

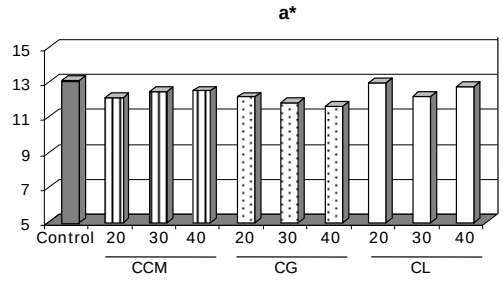
Data are mean ± S.D of the three salt amounts studied (see Methods).

B. Colour

Colour is one of the first information that consumers receive about food products. In this case, consumers typically associate a bright pink colour with cooked sausage.

The colour results of all the batches were very similar, independent of the type or amount of calcium salt added. The presence of calcium caused slight increases in the L* and b* parameters and a slight decrease in a* (Figure 1), but these differences did not achieve statistical significance.

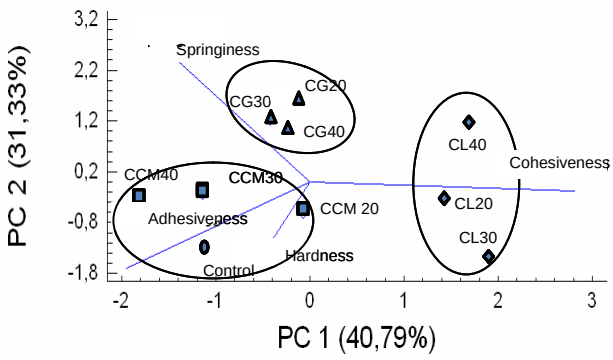
Figure 1: Effects of the calcium salt amount (% RDA) on the redness of experimental sausages



C. Texture analysis

TPA results were analyzed using covariance PCA. Two principal components accounted for 72.12% of the variation (Figure 2): PC1, 40.79%; and PC2, 31.33%. The most important parameter was cohesiveness, because it accounted for the greatest variation in PC1. The three types of calcium salt formed clusters with different texture properties: CL samples clustered around cohesiveness; CG samples clustered around high springiness, and CCM samples clustered together with the control batch, reflecting the similarity of their textures.

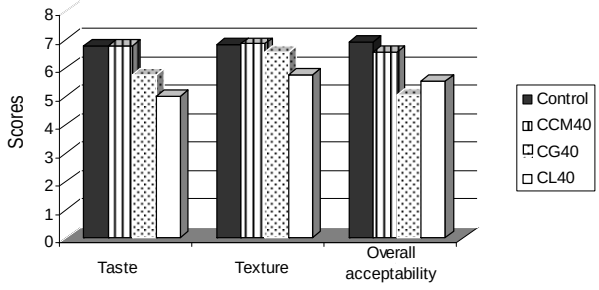
Figure 2: PCA of texture properties of experimental sausages prepared with different types of calcium salt.



D. Sensory analysis

The sensory properties of the sausages were evaluated using a hedonic test. Panellists rates as *good* the overall acceptability of batches enriched with 20 and 30% of calcium RDA (data not shown), and the scores of all batches were similar to those of the control. However, at 40% RDA of calcium, only the CCM score was similar to that of the control. The CG and CL batches scored lower than the control, mainly due to lower points on taste (Figure 3).

Figure 3: Hedonic assessment of sensory parameters of experimental sausages enriched with different calcium salts at 40% RDA.



IV. DISCUSSION

The differences in WHC between the control and calcium-enriched batches are a consequence of the increase in salinity as it has been observed in other meat products as a result of salt addition [9].

The change in the colour parameters L* and b* as a result of calcium salt addition were not enough to lead to a significant change in sausage colour. The same was true of the changes in the a* parameter, despite the whiteness of the calcium salts. These changes did not affect the sensory evaluations by panelists, who considered that the sausage colour was that expected for this type of meat product [14].

The texture analysis showed three clearly differentiated clusters according to the type of calcium salt added. Most importantly, the CL cluster showed greater cohesiveness than the other batches. This salt may interact with the meat proteins, increasing the firmness of the gel [7]. This higher cohesiveness translated into a lower score in the sensory analysis, though it was higher than 5, which is considered the limit of acceptability on this scale from 0 to 10.

The panellists gave acceptable scores to all the batches manufactured with 20-30% of the calcium RDA, although the CL and CG batches enriched with 40% of the RDA received lower scores. In fact, the CG score was significantly lower than that of the control ($p<0.05$). Batches added with 40% CCM were well accepted. Taste seemed to be the more influential parameter. Our results suggest that CG and CL can be used only up to 30% of the calcium RDA.

V. CONCLUSIONS

It is possible to manufacture cooked sausages enriched with CG, CL and CCM at 30% of calcium RDA and with good sensory quality. CCM gives good results even at 40% of RDA. Consequently, these products may be considered a *source of calcium*, and their commercialization would help increase the number of calcium-enriched products on the market.

ACKNOWLEDGMENTS

CONSOLIDER-Ingenio 2010 (CSD 2007-00016). Grupo 920276 UCM Tecnología de los Alimentos (GR35/10A) and AGL2007-63666.

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