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PROTEIN FUNCTIONALIZATION BY MECHANICAL ACTION

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I. INTRODUCTION

Protein functionalization through mechanical action has proven to be a promising approach to improve the functionality of meat cuts and raw materials [1]. The demand for high-quality meat products with better functionality drives the need for innovative processing methods. Mechanical action, including tumbling and High Pressure Processing (HPP), can be considered efficient alternatives for the solubilization and functionalization of myofibrillar proteins, improving the texture, juiciness, and stability of meat products [2] [3] [4]. The extraction of myofibrillar proteins can be performed by chemical, enzymatic, or mechanical methods. Chemical and enzymatic methods have limitations, such as the need for reagent neutralization and degradation of essential proteins. Mechanical action, such as tumbling and HPP, uses physical forces to solubilize proteins, preserving their functional properties. Additionally, HPP is a non-thermal process that uses high pressure to inactivate microorganisms and enzymes, which can improve the sensory characteristics of food [3] [5] [6]. This study aims to evaluate the influence of different mechanical processes on the extraction of soluble proteins (myofibrillar), focusing on improving the texture and functional properties of raw materials to increase water retention capacity and consequently yield, as a pre-processing step for the production of meat products.

II. MATERIALS AND METHODS

Whole pieces of pork round (*Semimembranosus muscle*) were collected at the factory and kept frozen at -18°C in polyethylene bags until the experiment was carried out, being thawed for 48 hours under refrigeration at 4°C±1°C after arrival at the Pilot Plant. The study was conducted in two stages (Table 1): first, different times and rotations were analyzed using the tumbling process, and subsequently, based on the results obtained, the pieces were subjected to the HPP process (Hiberbaric, Spain) considering pressures of 2000 bar and 4000 bar [4].

Table 1 – Treatments considered for Stages 1 and 2 of the experiment.

Stage 1	Stage 2
Standard (control without mechanical action)	Standard (control without mechanical action)
Tumbling 30 min: 5, 12 and 20 rpm	Tumbling 60 min 12 rpm
Tumbling 60 min: 5, 12 and 20 rpm	HPP pressure 2000 bar and 4000 bar 5 min at 5°C
Tumbling 90 min: 5, 12 and 20 rpm	Tumbling 60 min 12 rpm + HPP 2000 bar 5 min at 5°C
Tumbling 105 min: 5, 12 and 20 rpm	Tumbling 60 min 12 rpm + HPP 4000 bar 5 min at 5°C

After the tests were carried out, the samples were immediately frozen in a chamber at -18°C until the analyses were performed. The analyses included shear force measured with a Texture Analyzer (Model TA.XT2i Plus Texture Analyzer, Stable Micro Systems, USA), losses after process and sensory evaluation of appearance (color) and texture (tenderness, juiciness), whose results were validated using a simple, structured verbal or nominal scale [8], consisting of anchors ranging from absent to very. All analyses were performed in triplicate and statistically analyzed using ANOVA and Tukey's test through the software Jasp 0.18.3, with a significance level of 5%.

III. RESULTS AND DISCUSSION

In Stage 1 of the study, when relating instrumental results with sensory evaluations, it was observed that samples subjected to 60 minutes at 12 rpm, as well as 90 minutes at 12 and 20 rpm, performed better compared to the standard, providing greater tenderness and juiciness to the cuts (Figure 1). However, considering the factory's productivity, the treatment of 60 minutes at 12 rpm proved to be more viable and was selected for Stage 2. Overall, it was found that higher times and rotations have a negative impact on the evaluated parameters. Additionally, a period of 30 minutes was insufficient to open the fibers in a way that improves the texture.

In Stage 2, the color difference was clearly observed through visual analysis between the treatments (Figure 2). Samples subjected to a pressure of 4000 bar (with and without the tumbling stage) showed lighter coloration. Regarding losses after the process, as visually observed after the equipment exit, there was a tendency for differences in treatments only with HPP compared to the standard and other treatments (Figure 3).

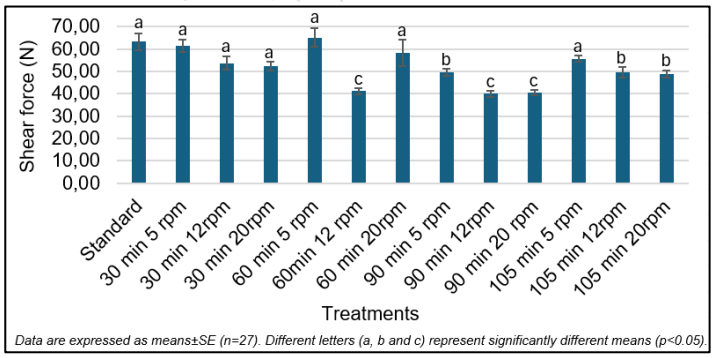


Figure 1. Shear force results according to the treatment.



Figure 2. Color comparison between treatments.

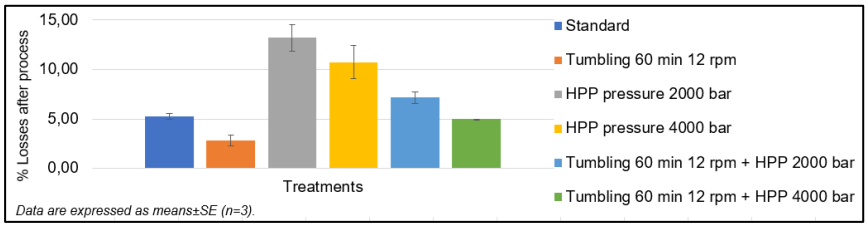


Figure 3. Results of losses after process.

Regarding the exudate, the treatments subjected to 2000 bar presented a more liquid aspect, while those subjected to 4000 bar showed a more viscous appearance, with a more pinkish/milky coloration, similar to the appearance of cooked product, along with the perception of a metallic residual. There was a difference in the coloration of the samples before preparation, however, no difference was noticed after oven preparation. Regarding the color of the meat, pressures of 2000 bar and 4000 bar, applied for 5 minutes at 5°C, are considered respectively the minimum and maximum limits for positive effects on the tenderization of pork cuts [4]. The meat becomes whitish after high pressure due to changes in the structure of myofibrillar proteins, in the distribution of water causing disorganization and opening of the fibers, which alters the texture and appearance. The association of HPP 4000 bar with tumbler brought positive texture, but with the perception of shredded meat. Probably the higher tested pressure resulted in significant changes in myofibrillar proteins, leading to a whitish appearance due to the loss of the ability to absorb and reflect light by the expulsion of water from the proteins [7].

IV. CONCLUSION

In Stage 1, the treatment of 60 minutes at 12 rpm was selected for Stage 2 due to its better instrumental and sensory performance, as well as process feasibility. HPP at 4000 bar improved tenderness and juiciness but promoted a whitish coloration and metallic residual due to protein denaturation, alteration of muscle fibers, and myoglobin. Pressures of 2000 bar were insufficient, while 4000 bar were too high, and both resulted in greater losses after the process, due to structural changes in the proteins. Thus, it is concluded that a pressure of 3000 bar may be a promising alternative to optimize meat quality by compensating for the adverse effects observed, potentially bringing the mapped benefits. This approach aims to ensure that the tests are assertive and meet the requirements of the manufacturing process, promoting quality in the final product.

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