OXIDATIVE AND MICROBIOLOGICAL STABILITY OF SEMI-FINISHED MEAT PRODUCTS WITH SOYBEAN-BARLEY PROTEIN-CARBOHYDRATE COMPOSITIONS DURING STORAGE

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Abstract. The purpose of this study was to evaluate storage-related oxidative and microbiological changes in semi-finished meat products containing a soybean-barley protein-carbohydrate composition (PCC). Control products were compared with formulations in which 20, 25 and 30% of meat raw material was replaced by PCC. Oxidative stability was assessed from the dynamics of peroxide value during the reported 0-300 day observation period, while microbiological stability was evaluated from the change in total viable microbial count (KMAFAnM) over the reported 0-360 day period and from the presence of indicator and pathogenic microorganisms. Peroxide value increased with storage time in all samples, but the increase was slower in PCC-containing products; the 25 and 30% variants remained close to or below the control values throughout the observation stages. Initial KMAFAnM counts were 1.2x10^2, 0.9x10^2 and 1.1x10^2 CFU/g for the 20, 25 and 30% PCC variants, respectively, compared with 2.1x10^6 CFU/g in the control. Coliforms, Listeria monocytogenes and Salmonella spp. were not detected. The results indicate that 25-30% PCC can improve the oxidative and microbiological stability of hybrid semi-finished meat products and may contribute to maintaining quality during storage.

Keywords: semi-finished meat product, soybean, barley, protein-carbohydrate composition, storage stability, lipid oxidation, peroxide value, microbiological safety, KMAFAnM

INTRODUCTION

Storage stability is a critical quality criterion for minced and semi-finished meat products because their dispersed structure exposes lipids and proteins to oxygen and increases the surface available for microbial development. Lipid oxidation is one of the principal non-microbial causes of quality deterioration in meat and can affect flavour, colour, nutritive value and consumer acceptability [1]. At the same time, microbiological growth determines product safety and practical shelf-life, making simultaneous control of chemical and microbiological changes essential.

One strategy for improving the stability of hybrid meat systems is the partial replacement of meat and fat components with hydrated plant-derived biopolymers. Such ingredients can alter the continuous phase of the product, bind water, modify oxygen diffusion and change the physical distribution of the lipid phase. The resulting matrix effects may influence both the rate of oxidative reactions and microbial development. Current research on plant-based ingredients and natural antioxidant systems confirms that changes in formulation can substantially affect peroxide formation and oxidative stability of meat products [2-4].

The dissertation underlying this thesis developed protein-carbohydrate compositions from soybean and barley and applied them to semi-finished meat products at replacement levels of 20, 25 and 30%. The previously prepared articles focused on transglutaminase-mediated structure formation and on nutritional and biological value. The present thesis deliberately addresses another part of the dissertation: the behaviour of the developed products during storage, especially lipid oxidation, volatile-component stability and microbiological indicators.

The aim of the work was to assess whether soybean-barley PCC affects the rate of peroxide accumulation and microbial growth during storage and to identify the replacement range associated with the most stable quality pattern.

MATERIALS AND METHODS

The study compared a control semi-finished meat product with experimental formulations containing 20, 25 and 30% PCC. The composition was based on soybean and barley raw materials together with hydrated functional components developed in the dissertation. The same general production conditions were applied to control and experimental samples so that changes could be related to the presence and level of PCC.

Oxidative stability was evaluated by monitoring peroxide value, expressed in mmol active O2/kg. The dissertation presents a storage curve covering 0-300 days. Peroxide value was used as an indicator of primary lipid oxidation because it reflects the accumulation of peroxides and hydroperoxides during the initial stages of oxidative deterioration. The analysis in the present thesis retains the original trend-based interpretation because the source figure provides the direction and comparative position of the curves rather than a complete numerical table for every time point.

Microbiological stability was evaluated from KMAFAnM (total viable aerobic and facultative-anaerobic microorganisms) and from indicator/pathogenic microorganisms. The dissertation presents initial KMAFAnM values for 20, 25 and 30% PCC products and for the control, together with a storage curve over 0-360 days. Coliform bacteria, Listeria monocytogenes and pathogenic microorganisms including Salmonella spp. were also assessed. The source states that the microbial increase was slower in PCC-containing samples and that 25-30% PCC showed the greatest stability during storage.

The dissertation additionally studied the composition of volatile compounds in the equilibrium gas phase, including organic acids, sulphur compounds, nitrogen-containing compounds, alcohols and ketones. These data were used qualitatively to support interpretation of aroma stability. No values absent from the dissertation are estimated in the present thesis.

RESULTS AND DISCUSSION

Peroxide value increased progressively in all formulations as storage time increased, confirming the expected development of primary lipid oxidation. The control showed the fastest increase and reached the highest level by the end of the reported 0-300 day observation period. In contrast, the PCC-containing samples exhibited a more moderate rate of peroxide accumulation. The 25 and 30% PCC variants were consistently described as remaining close to or below the control values at the corresponding storage stages.

Table 1. Main storage-stability findings for control and PCC-containing products

Assessment	Control	20% PCC	25% PCC	30% PCC
Initial KMAFAnM, CFU/g	2.1x10^6	1.2x10^2	0.9x10^2	1.1x10^2
Peroxide-value trend, 0-300 d	Fastest increase	Slower than control	Low/stable relative to control	Low/stable relative to control
KMAFAnM trend, 0-360 d	More rapid increase	Slower increase	Highest stability	Highest stability
Coliforms	Not detected	Not detected	Not detected	Not detected
Listeria monocytogenes	Not detected	Not detected	Not detected	Not detected

Salmonella spp.	Not detected	Not detected	Not detected	Not detected

The slower peroxide accumulation in PCC-containing products may be interpreted as a matrix effect rather than as evidence of a single antioxidant compound. The dissertation attributes the result to structuring of the lipid phase by biopolymers and partial limitation of oxygen diffusion. This explanation is compatible with general mechanisms of lipid oxidation in meat, where oxygen access, lipid distribution, pro-oxidant environment and the physical state of the matrix influence hydroperoxide formation [1]. Plant-derived ingredients and antioxidant systems have also been widely reported to slow lipid oxidation in meat products, although the magnitude of the effect depends strongly on composition and processing conditions [2-4].

The microbiological results show an equally clear separation between control and PCC variants at the initial assessment. KMAFAnM was 2.1x10^6 CFU/g in the control, whereas the 20, 25 and 30% PCC variants contained 1.2x10^2, 0.9x10^2 and 1.1x10^2 CFU/g, respectively. The experimental products therefore began the storage study with substantially lower total microbial counts. Coliforms, Listeria monocytogenes and Salmonella spp. were not detected in any of the listed samples.

During the reported 0-360 day monitoring period, KMAFAnM increased gradually in all samples, but the growth rate depended on formulation. The dissertation describes a more rapid increase in the control, particularly toward the later storage stages, while PCC-containing products remained below the stated regulatory limit throughout the observation. The 25 and 30% PCC formulations were identified as the most microbiologically stable variants. This pattern suggests that formulation and processing associated with PCC addition created conditions less favourable for rapid microbial development; however, the available dissertation data do not isolate the individual contributions of pH, water activity, ingredient microbiota or processing history.

The volatile-component analysis provides an additional quality perspective. In conventional minced-meat samples, storage was accompanied by increases in organic acids, nitrogen-containing compounds, alcohols and ketones, which the dissertation associates with the progress of biochemical and microbiological processes. PCC-containing products showed a comparatively more stable volatile profile, and sulphur-containing compounds did not increase sharply. This supports the conclusion that the experimental matrix helped maintain aroma-related quality during storage.

From a formulation standpoint, the 25-30% range produced the most favourable combined pattern. At these replacement levels, peroxide accumulation was restrained relative to control and the increase in total microorganisms was slower. The result is important because oxidative and microbiological deterioration are interconnected practical constraints in semi-finished meat products: a formulation that improves only one dimension may still have limited industrial value. The observed simultaneous improvement therefore strengthens the technological rationale for using soybean-barley PCC in hybrid meat systems.

It is important to distinguish the present conclusions from a formal shelf-life claim. The dissertation contains extended storage-duration statements in another section, but the primary figures used here present peroxide dynamics over 0-300 days and KMAFAnM dynamics over 0-360 days. Accordingly, this conference thesis limits its conclusion to comparative stability trends within the reported observation periods and does not establish a commercial expiry date. Confirmation of shelf-life for regulatory purposes would require a fully documented storage protocol, packaging conditions, temperature, replicate design and predefined microbiological acceptance criteria.

CONCLUSION

The soybean-barley PCC slowed the development of primary lipid oxidation in semi-finished meat products during the reported storage observation. The most stable peroxide-value pattern was observed for formulations containing 25-30% PCC.

PCC-containing products also showed substantially lower initial KMAFAnM values than the control, and the increase in total microorganisms during storage was slower. Coliforms, Listeria monocytogenes and Salmonella spp. were not detected in the reported samples.

The combination of restrained peroxide accumulation, slower microbial growth and a more stable volatile profile indicates that 25-30% PCC is a promising formulation range for maintaining the storage quality of hybrid semi-finished meat products. These findings provide a storage-focused research output that is independent of the previously prepared papers on structure formation and nutritional/biological value.

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