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UTILIZATION OF FLAXSEED PROTEIN-BASED O/W EMULSIONS WITH CENTAURY OIL AS FAT REPLACERS IN MODEL MEAT EMULSIONS

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I. INTRODUCTION

Meat is a rich source of essential nutrients; however, its high fat and cholesterol content has led to health concerns, prompting demand for low-fat alternatives. Besides that, reducing fat content and incorporating fat substitutes or vegetable oils can adversely affect the technological properties (such as cooking loss, emulsion stability, water-holding capacity, and texture) and sensory attributes [1]. Therefore, researchers have focused on incorporating valuable oils into meat product formulations using various techniques, to improve the quality and acceptability of reformulated low-fat meat products. The use of simple O/W emulsions in food systems is gaining attention due to their ability to efficiently deliver valuable oils while improving the nutritional and functional properties of the final product [2]. Flaxseed proteins are powerful multifunctional ingredients in food formulations due to their excellent techno-functional properties, preservation potential, and associated health benefits [3]. *Hypericum perforatum* L. contains several groups of compounds that contribute to its pharmacological activity. Studies have shown that centaury oil — a traditional herbal preparation typically obtained by macerating the flowering aerial parts of *Hypericum perforatum* in a carrier oil (such as olive oil) exhibits anti-inflammatory, antimicrobial, wound-healing, antioxidant, anxiolytic, antineoplastic, and antidepressant effects [4]. Therefore, the objective of this study was to evaluate the effects of O/W emulsion containing flaxseed protein and centaury oil, on the chemical composition and quality properties of model meat emulsions (MMEs).

II. MATERIALS AND METHODS

Fresh boneless beef and beef backfat were sourced from a local butcher in İzmir, Turkey. Centaury oil was purchased from Naturlife (Izmir, Turkey). Flaxseed protein isolate was obtained from cold-pressed flaxseed cake, kindly donated by Mecitefendi (Izmir, Turkey), using the method reported by Kaushik et al. [5]. Simple O/W emulsions used as a fat source in the MMEs were prepared by modifying the method described by Delgado-Pando et al. [6], using a formulation containing 2 parts flaxseed protein isolate, 8 parts water, and 10 parts centaury oil. Production of MMEs was carried out according to Cofrades et al. [7]. The formulations of MMEs were as follows: C (20% beef fat), E50 (50% beef fat was replaced by O/W emulsion), E75 (75% beef fat was replaced by O/W emulsion, and E100 (20% O/W emulsion). O/W emulsion stability was measured according to the methods of Surh et al. [8]. The moisture [9], fat [10], protein (LECO dry combustion analyzer, FP528, USA), and ash [9] contents were determined. The color (L*, a*, b*) of the emulsions was measured with a portable colorimeter (Konica Minolta, Japan). TBARS values were measured using methods by Witte et al. [11]. The model meat emulsion production procedure was replicated twice, resulting in two distinct batches produced on different days. Data were analyzed using ANOVA and Duncan's test (SPSS 23).

III. RESULTS AND DISCUSSION

Regarding the thermal stability (1 h at 70°C), centrifuge stability (3000 rpm, 3 min), and creaming stability (7 d at +4°C) there was no phase separation in the emulsion structures and the stability of the samples was high. L*, a*, and b* values of O/W emulsion were recorded as 62.64±0.8, 1.43±0.10 and 12.53±0.05, respectively. As the replacement of beef fat with the O/W emulsion increased, several notable changes were observed in the MMEs (Table 1). The moisture content progressively elevated, with the E100 exhibiting the highest moisture level compared to the control group ($P < 0.05$), indicating an enhancement in water retention. Conversely, the fat content decreased as more beef fat was substituted, with the E100 showing the lowest fat content compared to the control group ($P < 0.05$), confirming the intended reduction in fat. The protein content also exhibited a decline, from 27.52% in the control group to 16.22% in E100 ($P < 0.05$), which can be attributed to the lower protein content in the O/W emulsion compared to beef fat. Similarly, the ash content decreased with increasing levels of O/W emulsion replacement ($P < 0.05$), suggesting that the O/W emulsion contributed fewer minerals than beef fat. L* values reached the highest level in E100, indicating that the replacement of fat with the O/W emulsion increased lightness ($P < 0.05$). The a* values decreased as the level of fat replacement increased, with the E100 showing the lowest value, indicating a reduction in redness ($P < 0.05$). On the other hand, b* values increased with higher emulsion incorporation, reaching the highest value in E100, suggesting an increase in yellowness ($P < 0.05$).

Table 1. Chemical composition and color parameters of model meat emulsions

Treatments*	Chemical Composition				Color Parameters		
	Moisture (%)	Fat (%)	Protein (%)	Ash (%)	L*	a*	b*
C	64.93±0.41^{d}	5.55±0.02^{c}	27.52±0.48^{a}	1.99±0.10^{a}	67.70±0.01^{b}	4.83±0.02^{a}	7.69±0.07^{d}
E50	67.62±0.38^{c}	6.17±0.57^{c}	23.80±1.26^{b}	1.61±0.10^{b}	67.51±0.15^{bc}	3.81±0.08^{b}	9.18±0.13^{c}
E75	68.86±0.17^{b}	9.26±0.79^{b}	19.77±1.29^{c}	1.17±0.06^{c}	67.29±0.29^{c}	3.47±0.06^{c}	9.74±0.06^{b}
E100	70.36±0.50^{a}	12.24±0.90^{a}	16.22±0.44^{d}	1.04±0.01^{c}	68.67±0.13^{a}	2.81±0.03^{d}	9.90±0.07^{a}

*C: Control group containing totally beef fat, E50: 50% of beef fat was replaced by O/W emulsion, E75: 75% of beef fat was replaced by O/W emulsion, E100: Beef fat was totally replaced by O/W emulsion. $^{a-d}$: Different letters in the same column indicate a statistically significant difference ($P < 0.05$).

The TBARS values, indicating lipid oxidation, varied across the treatments. The control group had the lowest TBARS values, ranging from 0.40 to 0.92 ($P < 0.05$), suggesting minimal lipid oxidation with full beef fat. The E50 showed a significant increase in TBARS ($P < 0.05$), particularly in the 3rd and 5th days (1.69 and 1.82 mg MA/kg, respectively), indicating higher lipid oxidation with 50% beef fat replacement. The E75 exhibited slightly lower TBARS values (1.84 and 1.77 mg MA/kg) ($P < 0.05$), yet lipid oxidation increased over time. In contrast, the E100, with complete replacement of beef fat by the O/W emulsion, showed lower initial TBARS values, however oxidation increased at later time points. Nevertheless, during the storage period, none of the sample groups exceeded the prescribed limit for TBARS (<2 mg MA/kg, Witte et al. [11]), indicating that lipid oxidation remained within acceptable levels. This finding can be attributed to the antioxidant effects of centaury oil and flaxseed protein isolate.

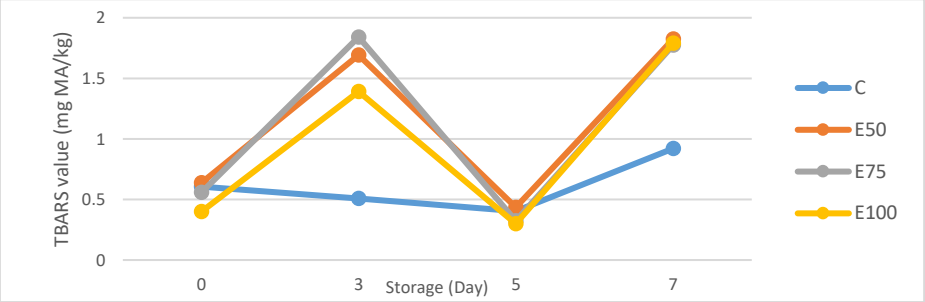


Figure 1. TBARS values of model meat emulsions

IV. CONCLUSION

The results of this study demonstrated that the incorporation of a simple O/W emulsion containing centaury oil and flaxseed protein isolate effectively reduced fat content while enhancing water retention in model meat emulsions. Although lipid oxidation increased with storage time, TBARS values remained within acceptable limits, likely due to the antioxidant properties of centaury oil and flaxseed protein isolate. Overall, the O/W emulsion shows promise as a functional fat replacer in the development of healthier meat products.

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