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SILVER-SKIN FOR DESIGNING "CLEAN-LABEL" PROCESSED MUSCLE FOODS: A CASE STUDY IN READY-TO-EAT RESTRUCTURED SALMON NUGGETS

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I. INTRODUCTION

Ready-to-eat (RTE) muscle foods are of common use in supermarkets owing to their ease to use and convenience. Yet, the susceptibility to oxidation reduces their shelf life, affects their sensory quality and leads to safety concerns. On the other hand, consumers are increasingly concerned on the use of classic additives as the interest in "*clean-label*" foods, is growing. Plant-source antioxidants are a promising alternative to classic antioxidant additives. Silver skin is a thin layer tightly adherent to coffee seeds and contains protein, dietary fiber, phenolic compounds, and melanoidins, etc [1]. Since it is a waste material from coffee production, its recycling in the design of muscle foods could be an interesting approach to fulfilling several objectives: i) promote circular economy; ii) reduce the number of classic additives; ii) enhance the quality and safety of processed muscle foods. Coffee silver skin has been incorporated into chicken meat burgers, and it was effective in reducing the warmed-over flavour [1]. The present paper was aimed at investigating the role of coffee silver skin on the oxidative stability of RTE restructured salmon nuggets during cold storage, and the color and texture properties of the nuggets were also evaluated.

II. MATERIALS AND METHODS

Salmon (*Salmo salar* L.) trimmings were obtained from a local supermarket in Cáceres (Spain) used as a pertinent model of muscle foods with high susceptibility to oxidation. Restructured salmon nuggets (cubes of approx. 2 cm height x 3 width x 4 cm long) were produced by adding 0.2% transglutaminase to trimmings (approx. 0.2 cm^3 particle size) along with 2% NaCl and 3.5% water and kept at chilling temperatures (4ºC) overnight. Two groups were produced depending on the addition (or absence) of silver skin (0.5%), namely, CONTROL and SILVER. Silver skin was obtained from Zeris Coffee Roaster (Cáceres, Spain). All samples were grilled (250ºC/2 min) and subsequently stored in an oxygen-permeable film at 4ºC for up to 28 days. Then, samples were reheated in a microwave (2 min/600 w) and analyzed for lipid oxidation (TBARS) [2], protein carbonylation (DNPH and HPLC)[2], and instrumental color and texture [3]. The entire experiment was carried out in triplicate and all analyses were made in duplicate (n=6). Data was analyzed by a student "t" test.

III. RESULTS AND DISCUSSION

Salmon nuggets with the addition of coffee silver skin had superior oxidative stability as compared to the control (Table 1). Throughout the storage period, the control group had significantly higher content of TBARS and carbonyls (measured by the HPLC method) than the treated one, indicating a greater degree of lipid and protein oxidation in the former. Generally, both lipid oxidation and protein oxidation in the control group progressed with increased storage time; while lipid oxidation was effectively inhibited by the addition of coffee silver skin as TBARS did not show major changes during storage. In the control group, TBARS appeared to decrease at day 28 as compared to day 21. It is likely that the reactive substances from lipid oxidation participated in further reactions. When detected by the DNPH method, protein carbonyls increased as expected. The DNPH method measures all the available protein carbonyl (primary and secondary carbonyl), while the HPLC method only measures primary carbonyl of AAS and GGS [4]. Lipid oxidation is known to be able to trigger secondary protein carbonylation, the large difference in protein carbonyl between the two methods suggested an important contribution from lipid oxidation. One contradictory finding was that the DNPH method revealed more protein carbonyls in the nuggets added with coffee silver skin. It is plausible that silver skin extracts could have contributed to increasing absorbance at 370 nm, leading to a misleading overestimation of total carbonyls. These results emphasize the higher accuracy and specificity of the HPLC-based protein carbonyl method over the DNPH spectrophotometric one.

The addition of coffee silver skin into salmon nuggets also affected the instrumental color and textural profiles (Table 2). Lightness, redness, yellowness all decreased, while hardness and adhesiveness increased in the silver skin

group. As color and texture are important quality aspects, sensory evaluation needs to be performed to assure the acceptance of the salmon nuggets with coffee silver skin.

Table 1. Oxidation of lipids and proteins of the salmon nuggets during cold storage.

Days	TBARS (mg MDA equivalent/kg meat)			Carbonyls (nmol/mg protein,DNPH)			Carbonyls (nmol/mg protein,HPLC)		
	CONTROL	SILVER	P-value[a]	CONTROL	SILVER	P-value	CONTROL	SILVER	P-value
1	0.28±0.07	0.02±0.00	***	10.04±0.62	11.43±1.76	ns	0.69±0.12	0.36±0.09	*
7	0.55±0.06	0.03±0.00	***	22.02±1.42	27.28±1.02	*	1.12±0.23	0.56±0.12	**
14	0.64±0.03	0.02±0.00	***	24.19±2.90	30.17±3.25	*	1.56±0.36	0.76±0.16	***
21	0.76±0.06	0.04±0.05	***	32.34±6.03	43.39±1.95	***	3.58±0.49	0.84±0.20	***
28	0.67±0.03	0.03±0.00	***	35.79±3.53	49.33±5.51	***	5.56±1.03	1.05±0.24	***

[a]the significance level: *, p < 0.05; **, p < 0.01; ***, p < 0.001; ns, not significant, p > 0.05

Table 2. Instrumental colour and texture profile analysis of the salmon nuggets at day 28.

Quality traits		CONTROL	SILVER	P-value[a]
Texture profile	Hardness[b]	7606±502	8487±560	*
	Adhesiveness[c]	18.17±2.31	20.46±1.07	*
	Springiness[d]	0.78 ± 0.03	0.79 ± 0.03	ns
	Cohesiveness[e]	0.63±0.07	0.63 ± 0.03	ns
	Gumminess[b]	4804 ± 520	5341 ± 620	ns
	Chewiness[c]	3759 ± 505	4252 ± 490	ns
	Resilience[d]	0.24 ± 0.05	0.24 ± 0.04	ns
Instrumental colour	Lightness[d]	69.53±0.46	56.93±0.56	***
	Redness[d]	14.34±0.79	10.39±1.12	***
	Yellowness[d]	18.10±1.47	14.12±2.66	***

[a]the significance level: *, p < 0.05; **, p < 0.01; ***, p < 0.001; ns, not significant, p > 0.05; Units: [b]: g; [c]:mm; [d]:dimesionless; [e]: g x mm.

IV. CONCLUSION

This study showed that coffee silver skin can be used as an effective natural antioxidant in ready-to-eat restructured salmon nuggets. The incorporation of silver skin led to altered texture profile and color, and therefore consumer's acceptance needs to be tested in the follow-up studies.

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