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EFFECTS OF *CODIUM FRAGILE* ON THE MANUFACTURING PROCESS AND QUALITY CHARACTERISTICS OF FERMENTED SAUSAGE AS A SALT REPLACER

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I. INTRODUCTION

Consumers demand healthier foods with an increasing interest in human wellness; therefore, various studies have been conducted on healthier meat products with reduced salt, fat, or replaced artificial additives [1]. In case of salt-reduced meat products, alternative salts such as $MgCl_2$, $CaCl_2$, and KCl, or natural substitutions containing high amount of salt, have been adopted as salt replacer in meat products [2]. Halophytes are the plants distributed near the sea in soils containing high amounts of salt [3]. A previous study reported that halophytes, when used as a salt replacer in sausage, reduced sodium absorption in mice [4]. The research hypothesis was that halophytes may act as pure-salt natural replacer. Thus, this study aimed to evaluate the possibility of dry fermented meat products replacing pure-salt with *Codium fragile*, a widely distributed halophyte.

II. MATERIALS AND METHODS

The *Codium fragile* (CF) used in the study was delivered after two days of harvest, freeze (F)/Hot-air (H) dried, consequently ground less than 500 μm size, and then mineral content of CF was determined using inductively coupled plasma mass spectrometry (Optima 8300DV, Perkin Elmer, Shelton, USA). Pork loin (80%), back fat (20%), and additives except for salt were used for making fermented sausages in the same ratio regardless of the treatment: 0.06% nitrite, 0.06% nitrate, 0.5% dextrose, and 0.025% Bactoferm F-LC starter culture (Chr. Hansen Holding A/S, Hoersholm, Denmark). The salt content of control (Con) was 2%, whereas that of treatments F-CF (2.14%; freeze-dried CF) and H-CF (2.47%; hot-air dried) was adjusted to the same as Na amount in 2 % salt. The fermentation process was conducted at 24℃ and 95% relative humidity and finished when the pH of the sausages reached 5.2.

The drying process was conducted at 15℃ with 90% to 75% relative humidity (gradually decreased by 5% every week) and finished when the moisture content of fermented sausage reached 35 % as defined by ‘Standards and Specifications for Each Food Products’ in ‘Food Code’ of Korea. The microbial growth, color, pH, texture profile analysis (TPA), and water activity of the fermented sausages were evaluated after final products were manufactured. The manufacturing process was conducted on three different days with three replicates. A one-way analysis of variance and Duncan’s multiple range post-hoc test (ver. 9.4; SAS Institute, Cary, NC, USA) were used to compare the quality characteristics of the fermented sausages between treatments. Statistical significance was considered at $p < 0.05$.

III. RESULTS AND DISCUSSION

The fermentation times for F-CF and H-CF were shorter than those of the control. F-CF showed significantly higher lactic acid bacteria (LAB) growth and total aerobic counts than Con ($p < 0.05$). Significant differences in total aerobic count after fermentation were found only between treatments, LAB and coagulase-negative staphylococci of treatment were significantly higher than Con ($p < 0.05$). Only LAB showed a significant difference after drying, and F-CF was higher than H-CF ($p < 0.05$). The quality characteristics of fermented sausages showed that lightness, redness, and pH were higher in the Con treatment than in the other treatments, whereas water activity was higher in the treatments than in the control ($p < 0.05$). Hardness, cohesiveness, and chewiness were significantly higher in the Con treatment than in the other treatments, whereas springiness showed significant differences ($p < 0.05$). The higher water activity of replacer-added fermented sausage, while no significant difference was found in moisture content (data not shown), resulted in relatively higher microbial growth during the manufacturing process. The pH declined significantly during fermentation, resulting in comparatively lower TPA values.

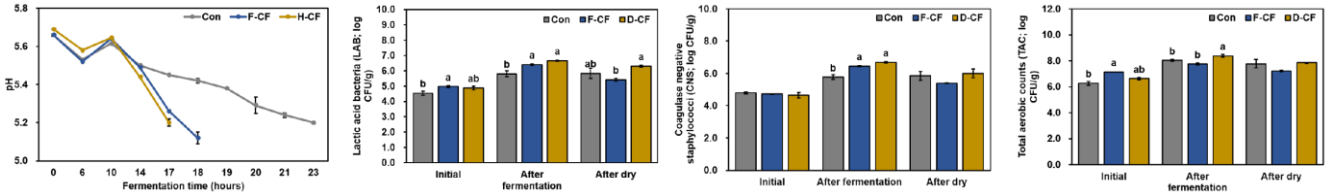


Figure 1. Changes in pH during fermentation and microbial growth of fermented sausage with different salt replacers. Data are means and standard error. Significant differences ($p < 0.05$) between the fermented sausage$^{(a-b)}$ with different salts represented with different letters. Con, 2% salt added; F-CF, 2% salt replaced with freeze-dried *Codium fragile*; H-CF, 2% salt replaced with hot-air dried *Codium fragile*.

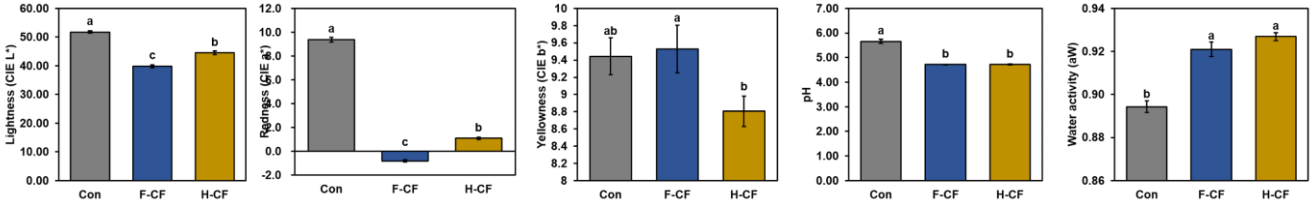


Figure 2. Color, pH, and water activity of fermented sausage with different salt replacers. Data are means and standard error. Significant differences ($p < 0.05$) between the fermented sausage$^{(a-c)}$ with different salts represented with different letters. Con, 2% salt added; F-CF, 2% salt replaced with freeze-dried *Codium fragile*; H-CF, 2% salt replaced with hot-air dried *Codium fragile*.

Table 1 - Comparison of texture profile analysis of fermented sausage manufactured with different salt replacers.

Traits	Con	F-CF	H-CF	PSE
Hardness (N)	50.71^{a}	40.72^{b}	37.76^{b}	1.612
Cohesiveness	0.51^{a}	0.38^{b}	0.38^{b}	0.012
Springiness	0.969^{ab}	0.960^{b}	0.975^{a}	0.002
Chewiness (N)	24.56^{a}	14.69^{b}	14.03^{b}	0.966
Adhesiveness (Nmm)	0.016	0.021	0.024	0.002

Data are means and pooled standard error (PSE).
Different superscripts ($^{a-b}$) indicate significant differences between the treatments ($p < 0.05$).
Con, 2% salt added; F-CF, 2% salt replaced with freeze dried *Codium fragile*; H-CF, 2% salt replaced with hot-air dried *Codium fragile*.

IV. CONCLUSION

Collectively, the addition of CF shortened the fermentation time of sausages and increased LAB and coagulase-negative staphylococci growth during fermentation. However, CF caused the fermented sausage to have a darker and greenish color. The texture of fermented sausages was modified by replacing salt with CF, regardless of the drying type. These results indicated that replacing salt with halophytes (CF) could shorten the fermentation time and modified the texture of fermented sausages.

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REFERENCES

1. Pateiro. M.; Munekata, P. E. S.; Cittadini, A.; Dominguez, R., Lorenzo, J. M. (2021) Metallic-based salt substitutes to reduce sodium content in meat products. Current opinion in Food Science 38:21-31.
2. Wang, J.; Huang, X. H.; Zhang, Y. Y.; Li, S.; Dong, X.; Qin, L. (2023) Effect of sodium salt on meat products and reduction sodium strategies – A review. Meat Science 205:109296.
3. Jin, S. K.; Cheng, H.; Kim, G. D. (2024) Evaluating the feasibility of using Salicornia herbacea powder as a salt substitute in sausage production. Food Science of Animal Resources published online ahead of print: Nov 21, 2024.
4. Jung, E. Y.; Lee, D. Y.; Kim, O. Y.; Lee, S. Y.; Yim, D. G.; Hur, S. J. (2020) Subacute feding toxicity of low sodium sausages manufactured with sodium substitutes and biopolymer-encapsulated saltwort (Salicornia herbacea) in a mouse mode. Journal of the Science of Food and Agriculture 100(2):794-802.