Effects of Salt and Nitrite on Warmed-Over Flavor in Cooked, Dried Beef after Supercritical Carbon Dioxide Extraction

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Abstract

Previous research shows that supercritical carbon dioxide (SC-CO_2) has potential in extraction of flavor compounds; warmed-over flavor (WOF) was successfully extracted from dried lean beef using SC-CO_2 extraction (Thongwong et al., 1999). However, stability after the extraction has not been fully established. Therefore, in this study, the effects of salt (2%), nitrite (100 and 200 ppm), and their combination (2% salt / 100 ppm nitrite and 2% salt / 200 ppm nitrite) were determined in pre-cooked, dried beef after the extraction of warmed-over flavor (WOF) using supercritical carbon dioxide (40°C 30 Mpa). A direct-heat distillation method and an automated headspace solid-phase micro extraction gas chromatography (auto-HS-SPME-GC) method were used to measure thiobarbituric acid (TBA) reactive substances and aldehyde (pentanal, hexanal, heptanal, 2,3-octanedione, and octanal) compounds, respectively. NaCl alone did not affect the development of WOF compounds because beef treated only with NaCl had the same levels of both TBA values and aldehyde contents as the control (P>0.05). Nitrite inclusion at both levels reduced WOF compounds by lowering TBA values and aldehydes concentration. Octanal concentration confirmed the previous research which showed that SC-CO_2 extraction could lower WOF compounds. However, no significant differences were found in TBA values or other aldehydes after 14 days storage. Results indicate that WOF compounds continue to be produced after SC-CO_2 extraction. Nitrite alone reduces WOF compounds, while NaCl alone does not. An implication of this result is that SC-CO_2 extraction does not provide long lasting reduction of WOF compounds unless curing agents are added after the extraction process.

Introduction

Warmed-over flavor (WOF) has long been known as an example of flavor deterioration for several heat-and-eat or ready-to-eat meat products. This problem is easily created in cooked meats which have been stored at 4°C for 48 hours. It is understood that the WOF is due to autoxidation of meat phospholipids and is also particularly noticeable after reheating the meat. Hydroperoxides are of importance in the development of meat off-flavor. They can further break down to smaller molecules and result in a formation of aldehydes, alcohols, acids, lactones, ketones and hydrocarbons (alkanes, alkenes, and alkynes). These are also increasingly detrimental to the development of warmed-over flavor in meats (Wilson et al., 1976).

Sodium nitrite, used in curing of meat, has shown great antioxidant activity in cooked meat. Sato and Hegarty (1971) reported that adding nitrite in concentrations as low as 50 ppm effectively prevents lipid oxidation and completely eliminates WOF at 2000 ppm. A comparative curing ingredient, salt (NaCl), has been reported as both a pro-oxidant and an antioxidant in meat products. NaCl at 1% or 2% levels act as a prooxidant, which increase lipid oxidation in meats during storage (Rhee et al., 1983). However, NaCl at 3% inhibited lipid oxidation (Rhee et al., 1983).

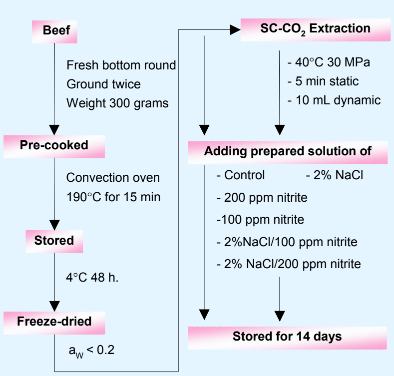
SC-CO_2 makes use of carbon dioxide at a temperature above its critical point (31°C and 7.38 MPa). Under these conditions, carbon dioxide behaves as both a liquid and a gas, which can selectively dissolve a wanted compound. A previous study showed that WOF compounds like hexanal and octanal could be extracted by supercritical carbon dioxide (Thongwong et al., 1999); however, the study of WOF development after the extraction has not been fully established.

Objectives

The objectives of this study were to determine (1) whether WOF is persistently produced and (2) the effects of NaCl (2%), nitrite (100 and 200 ppm), and their combination (2% NaCl/100 ppm nitrite and 2% NaCl/200 ppm nitrite) in pre-cooked, dried beef after the extraction of WOF compounds.

Materials and Methods

Sample Preparation



Measurement of TBARS values

The direct-heat distillation method with modifications of the method by Tarladgis et al (1960) was used to measure TBARS values. Five grams ± 0.01 of ground beef in a flat bottom distillation flask was subjected to direct-heat distillation using a stirring hot plate (Fisher Scientific, USA). Five mL of 0.02 M thiobarbituric acid was added and each screw capped glass tube was placed in a water bath (90°C) for 35 min. The absorbance of the reacted mixture was measured (λ = 538 nm) using a spectrometer (Spectronic 20, Bausch & Lomb Co., Rochester, NY).

Measurement of warmed-over flavor components

Auto-HS-SPME-GC method was used to determine concentrations of pentanal, hexanal, heptanal, 2,3-octanedione, and octanal in samples. The vial containing cooked, freeze-dried beef (1.5 g) and HPLC-grade water (3 mL) was heated at 75°C for 30 min then loaded into an auto sampler (Varian 8200 Auto Sampler, Walnut Creek, CA) connected to GC (Varian Star 3400 CX, Walnut Creek, CA). Helium (He) was used as a carrier gas at 1mL/min, the injector and detector temperature were set at 250 and 275°C, respectively, and a 85 µm carbon/PDMS stable flex SPME fiber (Supelco Co., Bellefonte, PA) was used for 20 min adsorption and 3 min for desorption to detect aldehydes in the headspace.

Statistical analysis

TBA values and GC data for the effect of salt and/or nitrite treatment were analyzed using the General Linear Model of SAS (SAS Inst. Inc., Cary, NC). All three replication were analyzed twice. The comparative analysis between means was conducted using least square mean contrasts at the significance level of 0.05.

Results

From the results of instrumental analysis and TBA test, pentanal, heptanal, and hexanal showed a highly significant degree of correlation with TBA values (figure 1). From figure 2, no significant differences were found between extracted and non-extracted beef after 14 days storage; however, octanal content was reduced and confirmed that SC-CO_2 extraction could lower WOF compounds. Even though the SC-CO_2 extraction at 40°C/30MPa successfully reduced the WOF compounds (Thongwong et al., 1999), this result implies that WOF compounds continue to be produced after SC-CO_2 extraction. Hexanal consistently had the highest peak for all samples followed by pentanal, heptanal, octanal and 2, 3 octanedione, respectively.

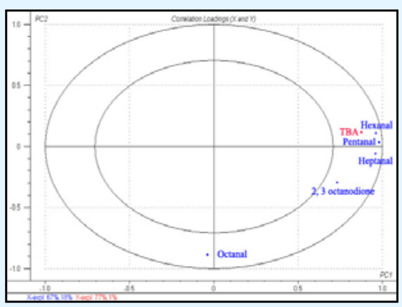


Figure 1: Diagram presents **correlation between TBA values and WOF components** of beef samples after 14 days storage.

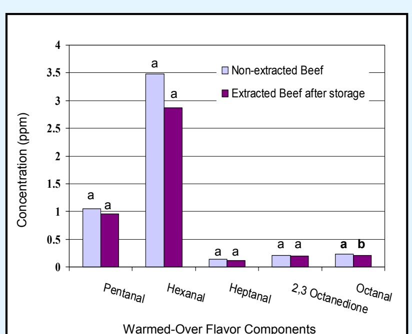


Figure 2: The comparison of mean of **WOF maker content (ppm) between extracted and non-extracted cooked, freeze-dried beef** by auto-HS-SPME-GC after 14 days storage

[ab] Means with the same letter do not differ significantly at p<0.05

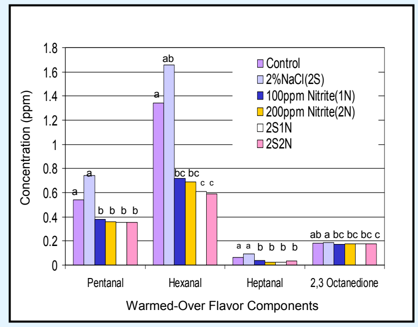


Figure 3: Mean of **WOF maker contents** (ppm) by auto-HS-SPME-GC for cooked, freeze-dried beef after SC-CO_2 extraction for 14 days

[abc] Means with the same letter do not differ significantly at p<0.05

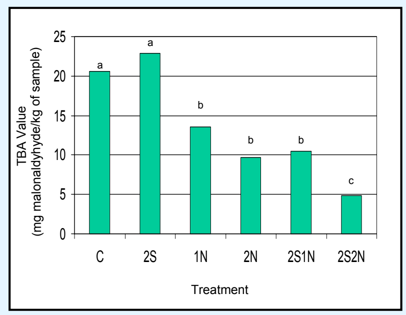


Figure 4: Mean of **TBA values** for cooked, freeze-dried beef, which already extracted the WOF compounds, after 14 days storage.

Note that: C=Control, 2S=2%NaCl, 1N=100ppm Nitrite, 2N=200ppm Nitrite, 2S1N=2%NaCl/100ppm Nitrite, 2S2N=2%NaCl/200ppm Nitrite

[abc] Means with the same letter do not differ significantly at p<0.05

NaCl alone did not affect the development of WOF compounds because beef treated only with NaCl had the same levels of both TBA values and WOF maker contents as the control (P>0.05) (figure 3-4). Nitrite inclusion at both levels reduced WOF compounds by lowering TBA values (figure 4) and concentration of WOF components (figure 3). Figure 4 indicated that nitrite with NaCl was more effective in decreasing WOF compounds than nitrite alone and the 2% NaCl/200 ppm nitrite combination had the lowest TBA value (p<0.05) of all treatments.

Conclusions

SC-CO_2 extraction could lower WOF compounds, but WOF compounds continue to be produced after the extraction.

Nitrite alone reduces WOF compounds, while NaCl alone does not.

Nitrite inclusion at both levels and the combination of nitrite and NaCl could reduce WOF compounds after the extraction of WOF compounds.

Although curing ingredients were added to the cooked samples after the extraction of WOF instead of raw meat, curing ingredients showed to have a great antioxidant effect in reducing WOF compounds.

References

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