Analysis of Ionic Compounds Contributing to the Quality of Rancidity in 17th Century Salted Beef

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INTRODUCTION

Historical documents note the sanitation conditions and the poor quality of food during the Age of Sail. In this study, 17th-century shipboard food items, specifically salted beef, were replicating using historical and archeological data. The meat was butchered according to remains found on the sunken English Galleon *Warwick* and was made based on the recipe obtained from the 1682 discourse *Salt and Fishery*. Using these specific replication methods has allowed for a more accurate analysis using the gas-chromatography mass-spectrometry (GC/MS) to quantify the presence of ionic compounds and to understand the flavor aromas.

The data gathered covering the varying values of the ionic compounds and the flavor aromas from the samples will allow for the quality of the rancidity to be accessed. Contributing to the overall aim of the project; studying the health and nutrition of 17th century sailors.

HYPOTHESIS

The replicated salted beef samples examined using the gas-chromatography mass spectrometry (GC/MS) are expected to show a decrease in hexanoic and butanoic acid, with an increase in hexanal. According to a study done in 2018 by Resconi et al., as beef gets older the concentration of aldehydes and ketones should increase, because they are the byproducts of lipid oxidation[1]. In this study, an increase in heptanal, hexanal, nonanal, pentanal, and octanal should be observed.

MATERIALS & METHODS

Frozen samples were placed in a jar and held in a water bath at 65°C, a temperature suitable for sensory analyses, and allowed to equilibrate for 30 minutes. As an internal standard, 10 uL of 1,2-dichlorobenzene was added to each sample. A solid-phase microextraction (SPME) portable field sampler was inserted through the lid of the jar and allowed to collect head space for 2 hours. The SPME was then injected into the injection port of a gas chromatograph for 3 minutes at an absorption of 280°C.Then, the sample was loaded on a gas chromatograph column using the order of the temperatures listed below.

- 40°C with a 1 minute hold
- 145°C at 5°C/min
- Increase at a rate of 20°C/min until reaching 250°C

The total run time of 28 minutes. The GC column then went to a mass spectrometer for quantification and identification using the Wiley Chemical Library. Chemical exceeding a quality report from the MS of 75 were used for analysis.

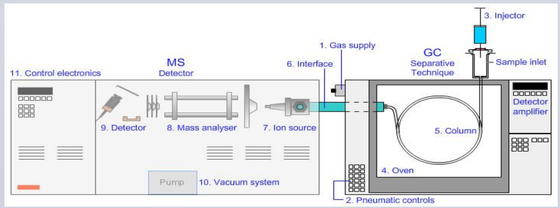

Figure 1. A diagram of the Gas Chromatography-Mass Spectrometry machine and how it works (CHROMacademy).

RESULTS

GCMS - Analysis

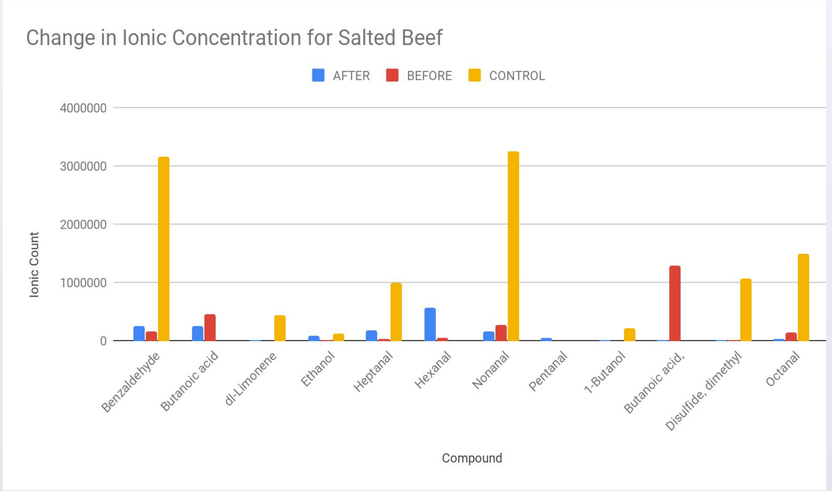

Figure 2. Quantitative data for each volatile compound found in the salted beef.

The flavor aroma within the samples is suggestive of lipid oxidation and deterioration of the salted beef during the preservation period.

The difference in ionic count is a contributor to the flavor aroma of the meat. Lipid oxidation and microbial growth are important factors that help catalyse the change in the ionic concentration. Thus, it is important to take note of

There are increased amounts of foreign scents from compounds in the after product, there was a significant increase in the ionic concentration of citrus flavor profile compounds- Octanal, d-Limonene, Heptanal, Nonanal- in the control subject that essentially overshadows the differences in the before and after samples.

	Benzaldehyde	Butanoic acid	dl-Limonene	Ethanol	Heptanal	Hexanal	Nonanal	Pentanal	1-Butanol	Butanoic, ethyl ester	Disulfide, dimethyl	Octanal
AFTER	254902	255154.5	20014.5	82897.5	183346.5	576382	166636.5	49230.5	20631	20603	12603	40599.5
BEFORE	167413	462879.5	0	18230	39412	53890	279609.5	0	0	1283507	10736.5	151824
CONTROL	3152504.5	0	442310.5	120434.5	986871.5	0	3245030.5	0	214564	0	1059260	1490324.5

Figure 3. Quantitative data of ionic concentrations for each volatile compound found in the salted beef.

DISCUSSION

A major factor in the nutritional quality and sensory perception of meat products is lipid oxidation. Lipid oxidation produces byproducts, such as aldehydes, that have a high chemical reactivity and are possibly harmful for human consumption[2].

Also, compounds associated with lipid oxidation can have unpleasant or pleasant aromas associated with them. Each sample was tested and the aromas associated with each compound is shown in **Figure 4**.

The rancidity of the meat may be unacceptable for today's standards, but based on historical data, sailors occasionally preferred and savored this form of brined meat.

COMPOUND	FLAVOR AROMAS
Hexanal	Green, grassy, fatty
N-Heptanal	Green, fatty, oily
Butanoic acid	Rancid
Benzaldehyde	Bitter Almond
Ethanol	Alcohol
Nonanal	Tallowy, Fatty
Butanoic acid, ethyl ester	Rancid
Butanol	Alcohol
Octanol	Waxy
Pentanal	Pungent
D-Limonene	Orange
Disulfide Dimethyl	Rancid, Garlic

Figure 4. The designated flavor aromas for each of the chemicals found in the beef.[4]

CONCLUSIONS & NEXT STEPS

During the 17th century, the specific preservation methods used to prepare and store the salted beef contributed to the overall rancidity of the meat. According to the flavor profile formed, the salted beef that the sailors consumed had a rancid, pungent, and sweaty flavor.[4] GC/MS data suggest that lipid oxidation, one of the key indicators of spoilage, occurred given that byproducts such as aldehydes were found in high amounts. In Sottero et al. (2019), the byproducts of lipid oxidation, were shown to cause genome damage.[3] More research will have to be conducted to determine a full risk analysis.

Overall, this project is in the preliminary stages of this section in the research. As the project continues, meat satisfaction regarding the 17th century flavor preference will be determined and included in all aspects of the project.

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