# Addition of freeze-dried beef exudate alters volatile flavor profile of cooked ground beef patties

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## I. INTRODUCTION

Beef flavor is composed of taste and aroma. Non-volatile taste contributing compounds include sugars, free-amino acids, small peptides, nucleotides, and others. Reducing sugars and free-amino acids, may also contribute to development of volatile beef aroma through the Maillard reaction. Water soluble heme iron containing myoglobin also contributes to beef taste [1]. Model studies have demonstrated hemoglobin and free iron contribute to beef aroma development [2]. Commonly beef is held in packaging under refrigerated temperatures. During this time water-based exudate is released in packaging. Meat exudate is rich in water-soluble compounds [3]. We hypothesized that meat exudate could be utilized to influence beef flavor. Therefore, the objective of this study was to determine if the addition of freeze-dried beef exudate to ground beef impacts volatile flavor compounds.

## II. MATERIALS AND METHODS

Beef exudate was collected from individually vacuum packaged *M. Longissimus lumborum* and M. Gluteus medius beef steaks following 28 d of refrigerated (4°C) storage. Approximately 500 mL of exudate was comingled from 96 steaks. After collection, exudate was frozen and stored at -80 °C in 50 mL conical vials. Conical vials were thawed at 4 °C for 24 hours before being freeze dried (VirTis Genesis 25L SQ Super ES-55 pilot lyophilizer, SP Scientific, Gardiner, NY). Dried exudate was added to 80:20 ground beef at 1 and 3%, by weight. A control treatment received no addition. Additions were made to to reach a final weight of 100 g before using a hand press to form beef patties. Nine patties were formulated per treatment. Patties were cooked on a cast-iron skillet heated to a surface temperature of 200 ± 10 °C to an internal temperature of 71 °C. Volatiles were collected by solid phase microextraction (SPME) using an 85 µm film thickness carboxen polydimethylsiloxane fiber (Supelco Inc., Bellefonte, PA, USA). After extraction, volatiles were separated by gas chromatography using a VF-5ms capillary column (30 m × 0.25 mm × 1 µm; Agilent J&W GC columns, Santa Clara, CA, USA). Compounds were measured by quadrupole mass spectrometer (5977A, Agilent, Santa Clara, CA, USA) via electron ionization at 70 eV. External analytical grade standards (Sigma-Aldrich, St. Louis, MO, USA) were used to confirm compound identities through retention time and the fragmentation patterns. Quantitation of volatile compounds (ng per gram of sample) was conducted using the internal standard and a 5-level calibration curve.Statistical analyses were conducted using the PROC GLIMMIX procedure of SAS (v. 9.4, Cary, NC, USA). The Kenward-Roger adjustment was used to estimate denominator degrees of freedom. Least squares means were separated using the PDIFF function. Alpha was predeterimend to be 0.05.

# III. RESULTS AND DISCUSSION

Among measured compounds 24 differed due to treatment ( $P \le 0.046$ , Table 1). Strecker aldehydes, Methional, Benzaldehyde, and Phenylacetaldehyde were greater in the 3% treatment compared to all others (P < 0.05). Therefore, 3% inclusion of dried exudate into beef patties may provide additional free-amino acid precursors to participate in the Maillard reaction. Conversely, Acetoin was greater in control samples compared to 3% (P < 0.05). Acetoin is an odor active intermediate of the Maillard reaction which may generate Strecker aldehydes [4]. Lower Acetoin with 3% inclusion of dried exudate

may be due to enhanced participation of Acetoin in the Strecker degradation pathway. Among lipid derived volatile compounds, Nonanoic acid, Decanal, 2,4-Decadienal, 2-Undecenal, and Decane were greater in the 3% treatment compared 1% and control treatments (P < 0.05). Conversely, Methyl butyrate, Methyl Heptanoate, Pentanal, 2-Heptanone, and 2-Pentylfuran were each greater in control compared to all others (P < 0.05). Methyl octanoate and Hexanal were each greater in control compared with 3% (P < 0.05). Lipid degredation products may participate in the Maillard reaction [5]. Therefore, inclusion of dried exudate may influence interactions among Maillard intermediates and lipid degradation compounds.

Table 1 – LS means of volatile compounds (ng/g) from cooked ground beef patties (control) or ground beef patties contining 1 or 3% freeze-dried beef exudate by weight.

Volatile Compound	Control	1%	3%	SEM <sup>1</sup>	P-value
Benzaldehyde	7.23 <sup>b</sup>	8.15 <sup>b</sup>	9.75 <sup>a</sup>	0.44	<0.001
Methional	0.64 <sup>b</sup>	0.77 <sup>b</sup>	1.32 <sup>a</sup>	0.11	<0.001
Phenylacetaldehyde	4.82 <sup>b</sup>	5.11 <sup>b</sup>	6.59 <sup>a</sup>	0.31	<0.001
Acetoin	21.0 <sup>a</sup>	19.5 <sup>ab</sup>	15.3 <sup>b</sup>	1.32	0.015
Carbon Disulfide	24.7 <sup>b</sup>	171.4 <sup>a</sup>	189.4 <sup>a</sup>	33.3	0.003
Furfuryl Sulfide	42.21 <sup>a</sup>	12.54 <sup>ab</sup>	8.88 <sup>b</sup>	6.55	0.027
1-Pentanol	6.57ª	5.87 <sup>b</sup>	5.93 <sup>b</sup>	0.21	0.04
2-Heptanone	4.84 <sup>a</sup>	4.74 <sup>b</sup>	4.68 <sup>b</sup>	0.03	0.003
2-Pentyl Furan	4.73 <sup>a</sup>	4.60 <sup>b</sup>	4.61 <sup>b</sup>	0.04	0.036
2-Undecenal	1.56 <sup>b</sup>	1.57 <sup>b</sup>	1.97 <sup>a</sup>	0.07	<0.001
2,3-Pentanedione	6.81 <sup>b</sup>	7.48 <sup>ab</sup>	7.73 <sup>a</sup>	0.23	0.023
2,4-Decadienal	0.45 <sup>b</sup>	0.46 <sup>b</sup>	0.55 <sup>a</sup>	0.02	<0.001
D-Limonene	4.40 <sup>a</sup>	4.39 <sup>ab</sup>	4.38 <sup>b</sup>	0.003	0.013
Pentanal	11.8ª	9.11 <sup>b</sup>	8.32 <sup>b</sup>	0.78	0.009
Hexanal	42.4 <sup>a</sup>	26.0 <sup>ab</sup>	22.5 <sup>b</sup>	4.67	0.014
Octanal	21.9 <sup>a</sup>	16.0 <sup>b</sup>	20.4 <sup>ab</sup>	1.62	0.046
Nonanal	15.9 <sup>a</sup>	12.3 <sup>b</sup>	13.7 <sup>ab</sup>	0.89	0.028
Decanal	4.51 <sup>b</sup>	4.34 <sup>b</sup>	4.99 <sup>a</sup>	0.09	<0.001
Methyl Butyrate	5.38 <sup>a</sup>	4.98 <sup>b</sup>	4.98 <sup>b</sup>	0.05	<0.001
Methyl Heptanoate	4.77 <sup>a</sup>	4.75 <sup>b</sup>	4.76 <sup>b</sup>	0.004	<0.001
Methyl Octanoate	4.19 <sup>a</sup>	4.17 <sup>ab</sup>	4.15 <sup>b</sup>	0.01	0.034
Nonanoic Acid	5.89 <sup>b</sup>	5.92 <sup>b</sup>	6.06 <sup>a</sup>	0.04	0.009
Octane	8.45 <sup>b</sup>	10.25 <sup>ab</sup>	10.63 <sup>a</sup>	0.61	0.042
Decane	2.90 <sup>b</sup>	3.07 <sup>b</sup>	3.38 <sup>a</sup>	0.05	<0.001

<sup>1</sup>Standard error of the mean (SEM) pooled among all mean comparisons. <sup>a,b</sup>LS means within a row lacking a common superscript differ (P < 0.05).

## IV. CONCLUSION

Dried meat exudate added to ground beef influence volatile flavor compound formation. Sensory evaluation should be conducted to confirm impact on beef flavor attributes.

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