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Flavour attributes and fatty acid profile that differentiate beef based on country of origin (#619)

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Introduction

Beef flavour is a complex attribute that results from the interaction of taste, aroma and tactile senses from the tongue, nasal, sinus and oral cavities (Kerth & Miller, 2015). Its complexity arises from the influence of both pre-mortem (e.g. production system/feeding regime) and post-mortem (e.g. cooking/storage conditions) (Adhikari et al., 2011) factors on the production of different beef flavour precursors and compounds. While tenderness and juiciness have received much attention over the years, recent research, however, shows that beef flavour could in fact be more influential in driving consumer liking and differentiating beef with substantial economic implications (Kerth & Miller, 2015).

The purpose of the present study was to explore flavour lexicons that can be used to differentiate beef from different countries and to observe how fatty acid profiles may contribute to this variation in beef flavour.

Methods

Twelve ribeye (*Longissimus thoracis*) primals from 3 different regions (Canada; AAA, United States; CHOICE and Australia; MSA4, n = 12) were aged for 45 days and collected frozen. Two steaks (1 inch) from each loin were cut, thawed overnight under refrigeration and grilled to internal temperature of 71ºC. Steaks were presented to a 9-person trained panel to rate the intensity of aroma and flavour attributes using a 15-cm line scale.

Intramuscular lipids were extracted using a mixture of chloroform–methanol (2:1, v/v) according to Folch et al. (1957). Fatty acid methyl esters (FAME), branched-chain FAME, conjugated linoleic acid isomers and other biohydrogenation intermediates were analyzed using gas liquid chromatography as described in previous literature (Kramer et al. 2008; Turner et al. 2011).

Analysis was done using XLSTAT (version 2019.1) with country of origin as main effect, and animal as random effects. Significant level was defined as p<0.05. Means were separated using Tukey's mean separation technique.

Results

Among the aroma attributes evaluated, beefy, bloody/metallic, buttery, cocoa, livery and off-sour were significantly different among the beef steaks from the three regions (Table 1). While all these attributes except cocoa were also found significantly different for flavour among the beef, the basic gustatory taste that was found to differentiate beef samples were "sour" and "umami" attributes (Table 2). Generally, beef from Australia (AUS) was rated as the highest in bloody/metallic, off-sour and livery aroma as well as lowest in buttery aroma intensity. In addition, beef from Canada (CAN) and United States (USA) were similar with higher intensity rating for beefy and buttery flavour while AUS was rated with the highest intensity for bloody/metallic, livery, off-sour, off-flavour, and sour flavour (Table 2).

While Maughan et al. (2012) associated some flavour attributes with consumer liking, it is important to note that consumer preferences are largely based on past experiences (Sañudo et al., 2000). In this case, consumer flavour preferences in various regions will vary and could be considered in product differentiation strategies for beef export markets. The present results correspond with consumer data previously reported where Canadian consumers least preferred AUS beef compared to USA and CAN (Gaudette et al., 2018).

In the current study, AUS had the highest percentage of saturated (SFA), omega 3 (n-3) and t11-18:1 (a known substrate for CLA synthesis) fatty acids compared to CAN and USA (Table 3). This is perhaps indicative of a higher proportion of grass/hay diet for the Australian cattle used in this study. Grass-fed animals typically have higher muscle concentrations of n-3 polyunsaturated fatty acids (PUFA) (Sañudo et al., 2000). The high SFA in AUS could also be due to the susceptibility of long chain dietary PUFA (e.g. n-3) to rumen biohydrogenation (Scollan et al., 2001), converting the PUFA to SFA. A trend was also observed for higher C18:2n-6 and total n-6 FA in USA and CAN, a possible indication of the grain feeding system in these regions.

A PUFA/SFA and n-6/n-3 ratio of >0.4 and <4 respectively, are recommended in human diets for health reasons (Wood et al., 2004). While the PUFA/SFA ratios for beef used in this study were not significantly different, AUS and CAD beef had n-6/n-3 ratios closer to recommended values while USA ratios were further from the recommended (Table 3).

Overall, the fatty acid profile explained up to 39% of the variation in flavour and aroma intensities perceived by trained panelists. The beef samples were well separated by country of origin based on principal component (PC) 1 (22%), with AUS closely associated with off-sour, livery, bloody/metallic, earthy/cooked vegetable, and off-flavour (Fig. 1). On the other hand, both USA and CAN were widely described as beefy, buttery and umami. Furthermore, while n-3, t11-18:1 and saturated FA were mostly associated with AUS beef, USA and CAN were mostly associated with MUFA and n-6 fatty acids.

Conclusion

Different feeding regimens as well as animal breed could impact the variation in beef flavour/aroma intensities. The attributes appreciated by consumers may vary across regions and these could be identified and targeted for successful differentiated beef export trade.

Notes

Table 3: The effect of country of origin on beef fatty acid profile

Country of Origin*	Fatty Acid Composition														
	SFA (%)	C16:0 (%)	C18:0 (%)	cMUFA (%)	tMUFA (%)	t10-18:1 (%)	t11-18:1 (%)	PUFA (%)	C18:2n-6	C18:3n-3	CLA (%)	n-3 (%)	n-6 (%)	n-6/n-3	PUFA /SFA
USA	45.143^{b}	25.702^{ab}	14.668^{b}	41.123^{b}	7.509^{a}	5.432^{a}	0.588^{b}	4.028	3.010	0.131^{c}	0.481^{a}	0.273^{c}	3.755	15.103^{a}	0.088
CAN	46.205^{b}	27.106^{a}	13.783^{b}	45.220^{a}	2.656^{c}	1.393^{c}	0.433^{b}	3.915	2.538	0.224^{b}	0.308^{b}	0.474^{b}	3.445	7.470^{b}	0.083
AUS	48.313^{a}	25.381^{b}	18.124^{a}	40.534^{b}	5.198^{b}	2.717^{b}	1.414^{a}	3.855	2.605	0.278^{a}	0.436^{a}	0.628^{a}	3.227	5.119^{b}	0.078
SEM	0.559	0.407	0.254	0.546	0.230	0.228	0.117	0.166	0.132	0.011	0.023	0.030	0.148	0.797	0.004
P value	**0.004**	**0.029**	**< 0.0001**	**0.008**	**< 0.0001**	**< 0.0001**	**< 0.0001**	0.760	0.049	**0.001**	**< 0.0001**	**< 0.0001**	0.069	**< 0.0001**	0.280

a-c Values with different letters on the same column are significant at p<0.05. *CAN; Canada, AUS; Australia, USA; United States.

Table 3
The effect of country of origin on beef fatty acid profile

Table 1: Variation of beef aroma attributes with country of origin

Country of Origin*	Aroma Attributes											
	Beefy	Bloody / Metallic	Dairy / Cooked Milk	Buttery	Cocoa	Earthy / Cooked Vegetable	Livery	Off-Sour	Wheaty / Grainy	Off-Aroma / Other	Fatty	Asparagus
USA	7.358^{a}	1.348^{b}	0.713	1.424^{a}	0.299^{a}	1.385^{b}	0.564^{b}	0.467^{b}	1.170	0.238	2.469^{a}	0.780
CAN	6.893^{ab}	1.424^{b}	0.807	1.370^{a}	0.336^{a}	1.545^{ab}	0.739^{b}	0.574^{b}	1.155	0.372	2.324^{ab}	0.782
AUS	6.435^{b}	1.838^{a}	0.808	1.006^{b}	0.244^{b}	1.735^{a}	1.531^{a}	0.965^{a}	1.262	0.515	2.170^{b}	0.932
SEM	0.166	0.075	0.042	0.060	0.015	0.100	0.090	0.085	0.077	0.088	0.079	0.075
P value	**0.005**	**0.001**	0.221	**<0.0001**	**0.002**	0.075	**< 0.0001**	**0.002**	0.584	0.117	0.054	0.285

a-b Values with different letters on the same column are significant at p<0.05. *CAN; Canada, AUS; Australia, USA; United States.

Table 2: Variation of beef flavour attributes with country of origin

Country of Origin*	Flavour Attributes													
	Sour	Umami	Asparagus	Beefy	Buttery	Cocoa	Earthy / Cooked Vegetable	Livery	Bloody / Metallic	Off-Sour	Wheaty / Grainy	Dairy / Cooked Milk	Fatty	Off flavour / Other
USA	1.252^{b}	3.702^{a}	0.552^{b}	6.393^{a}	1.794^{a}	0.125	1.378^{b}	0.556^{b}	1.585^{b}	0.619^{b}	1.124	0.769	3.186	0.139^{b}
CAN	1.338^{ab}	3.527^{ab}	0.704^{ab}	5.996^{a}	1.657^{a}	0.142	1.463^{b}	0.898^{b}	1.591^{b}	0.886^{b}	1.093	0.913	2.985	0.196^{ab}
AUS	1.532^{a}	3.380^{b}	0.885^{a}	5.420^{b}	1.316^{b}	0.140	1.937^{a}	2.025^{a}	1.919^{a}	1.371^{a}	1.137	0.776	2.726	0.432^{a}
SEM	0.074	0.076	0.102	0.130	0.086	0.025	0.120	0.143	0.093	0.114	0.059	0.074	0.164	0.070
P value	**0.046**	**0.030**	0.100	**<0.0001**	**0.005**	0.882	**0.010**	**< 0.0001**	**0.034**	**0.001**	0.866	0.327	0.174	**0.023**

a-b Values with different letters on the same column are significant at p<0.05. *CAN; Canada, AUS; Australia, USA; United States.

Table 1 & 2
Table 1: Variation of beef aroma attributes with country of origin

Table 2: Variation of beef flavour attributes with country of origin

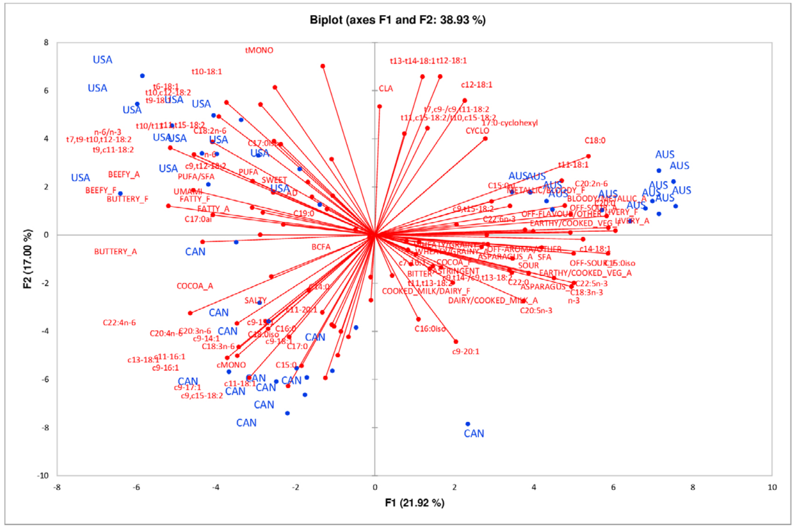

Figure 1: Principal component analysis of beef from three different countries of origin and their fatty acid profile

Figure 1
Principal component analysis of beef from three different countries of origin and their fatty acid profile

Notes