RELATIONSHIP BETWEEN CAROTENOIDS AND INTRAMUSCULAR FAT CONTENT IN CATTLE

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ABSTRACT

The purpose of this study was to determine the relationship between β-carotene and lutein in meat, subcutaneous, intermuscular and intramuscular fat of cattle as well as their relationship with the fat content of meat. Many correlations between β-carotene and lutein in the different adipose tissues and meat were demonstrated. Very high correlations were also observed between the fat content of meat (marbling) and the predicted intramuscular fat based on β-carotene and lutein. Results indicate that estimates of carotenoids in meat and adipose tissue using HPLC can give an accurate estimate of intramuscular fat content in cattle.

Keywords: β-carotene, lutein, intramuscular fat, marbling, meat, carotenoids

INTRODUCTION

There is a considerable concern in Australia about the quantity and nature of the fat in red meat in relation to human health. On the other hand, certain countries importing Australian beef desire meat with high intramuscular fat content (marbling). Carcasses with high marbling scores attract price premiums on the Korean and Japanese markets. However, marbling as a subjective estimate does not always correlate well with intramuscular fat obtained by solvent extraction (Kogel *et al* 1993). In our studies on the genetics and metabolism of carotenoids in cattle, we have found a moderate correlation between the β-carotene concentration in meat and subcutaneous fat. This led us to investigate the interrelationship of the two major cattle carotenoids, β-carotene and lutein, in meat, subcutaneous, intermuscular, intramuscular fat and their relationship with the fat content of beef.

MATERIAL AND METHODS

Animals and management. Limousin and Jersey cows, 15 per breed, were used for the study. The cows were part of the Davies Cattle Gene Mapping Herd maintained at Martindale in South Australia. They were randomly chosen from 70 cows slaughtered in February 1998. The animals were under the same management and grazed on the same pasture receiving a supplement of hay and silage.

Sample collection and preparation. Meat and adipose tissue samples were collected from carcasses after overnight in the chiller. Slices of muscle and attached subcutaneous fat (1-2 cm in thickness) were cut from 10^{th}-11^{th} rib as a cross-section from the *M. longissimus dorsi*. The samples were stored at -20^{0}C in sealable plastic bags until analysed. Prior to chemical analysis, subcutaneous and intermuscular fat were dissected from the meat, and the meat samples (100g) homogenised in a food processor to a fine paste. All samples were freeze-dried prior to analyses and stored at -20^{0}C.

Chemical analyses. β-carotene and lutein in meat and fat were determined by methods described by Kruk *et al* (1997a, b) respectively and quantified by high performance liquid chromatography (HPLC) (Hewlett-Packard, model 1100, USA). Separation was achieved using a Spherisorb ODS column (5 µm, C18 250 X 4.6 mm) which was protected by a pre-column guard cartridge. The mobile phase was a methanol:hexane:water (90:5:5) mixture with a flow rate of 1.2 ml/min. Analytical standards of β-carotene, lutein and alpha tocopherol acetate (internal standard) were obtained from Fluka. Intramuscular fat was extracted from homogenised meat samples (10g) with chloroform:methanol (2:1) according to the method of Christie (1989).

Statistical analyses. Statistical analysis was performed using Proc CORR (SAS 1989). Test of significance (difference from 0) at $P<0.05$ was determined by BONFERRONI probabilities. To obtain the predicted fat content, β-carotene or lutein concentration in the meat (expressed as µg/g meat) was divided by its concentration in the subcutaneous fat (expressed as µg/g of subcutaneous fat) according to the equation:

$$\text{Predicted fat content} = \frac{\text{concentration of β-carotene (or lutein) in the meat (µg/g)}}{\text{concentration of β-carotene (or lutein) in the subcutaneous fat (µg/g)}}$$

RESULTS

Correlations between β-carotene and lutein. There was a number of correlations observed between β-carotene and lutein within and between meat, subcutaneous, intermuscular and intramuscular fat samples (Table 1). Lutein in the meat was associated with β-carotene concentration in subcutaneous, intermuscular and intramuscular fat and the correlations were moderate. Also a moderate correlation between lutein and β-carotene in the meat was observed. It was the only correlation between these carotenoids within the same tissue. The relationship of β-carotene between different tissues was more evident in the adipose tissues where β-carotene concentration was highly correlated. β-Carotene in meat was only correlated with subcutaneous and intermuscular fat.

Lutein content was also associated in the fat tissues. However, there was no correlation with lutein content in the meat. All correlations of β-carotene between different tissues and lutein between different tissues were positive, moderate to high.

Correlations between fat content in muscle. Fat content in meat was compared with the predicted fat content based on the concentration of β-carotene and lutein in meat and in subcutaneous fat. The correlations between measured fat content and the fat content predicted on β-carotene and lutein were 0.9997 and 0.9978, respectively. Thus, the predicted fat content estimates were very highly correlated with measured fat content and between each other.

Table 1. Correlations of β-carotene and lutein in different fats and meat.

Tissue		Meat		Subcutaneous		Intermuscular		Intramuscular	
		BC	LU	BC	LU	BC	LU	BC	LU
Meat	BC	X							
	LU	0.64	X						
Subcutaneous fat	BC	0.84	0.46	X					
	LU	ns	ns	ns	X				
Intermuscular fat	BC	0.85	0.49	0.87	ns	X			
	LU	ns	ns	ns	0.93	ns	X		
Intramuscular fat	BC	ns	0.64	0.66	ns	0.90	ns	X	
	LU	ns	ns	ns	0.73	ns	0.80	ns	X

Note: BC=β-carotene, LU= lutein, ns=not significantly correlated ($P > 0.05$)

DISCUSSION

β-Carotene and lutein are fat soluble components which are deposited in adipose tissue of cattle and cause yellow fat colour (Strachan *et al* 1993). A high correlation between β-carotene concentration in meat and in the various adipose tissues confirms our previous observations. High positive correlations of β-carotene and lutein between subcutaneous, intermuscular and intramuscular fat in this study indicate that their deposition is similar in all types of adipose tissues. Since β-carotene and lutein are fat soluble and are highly correlated in their adipose deposition, we hypothesized that the vast majority of the carotenoids would be present in the fat cells rather than in the muscle cells. Hence, carotenoid content in meat would be directly related to the fat content of the meat. If true, it would be possible to predict intramuscular fat content based on these fat soluble components.

The high correlation between total lipids extracted from meat and the predicted fat content in meat based on β-carotene and lutein shows clearly that the HPLC quantitation of carotenoids in meat and adipose tissue can be an accurate measurement of fat content in cattle. This is invaluable because there is no other accurate method of estimating fat content (marbling) in live animals. Since total lipid extraction is tedious, time consuming and requires a large quantity of meat, the prediction of fat content based on β-carotene and lutein can also be a competitive substitute for fat quantitation in slaughtered animals.

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