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REVIEW PAPER

HEALTH-SUPPORTING PROPERTIES OF BEEF

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Abstract

Contemporary human diet contains excessive quantities of *n*-6 saturated fatty acids (SFA) and polyunsaturated fatty acids (PUFA), but it is deficient in *n*-3 fatty acids. This imbalance could be the cause of respiratory diseases, obesity and cancer. Until recently, animal fat, including meat fat, was regarded solely as a source of saturated fatty acids, which are a risk factor for atherosclerosis, obesity and certain types of cancer. Recent studies have shown, however, that animal fats contain biologically active substances beneficial for health, and that only some saturated fatty acids have adverse consequences. The latter group includes lauric acid (C12), myristic acid (C14) and palmitic acid (C16), i.e. mainly the ones with an unfavorable *n*-6/*n*-3 fatty acid ratio. Apart from fat, beef also contains high amounts of minerals, mainly phosphorus, potassium, magnesium and zinc.

Conjugated linoleic acid (CLA), in particular its cis-9 trans-11 and trans-9 cis-11 isomers, is one of the substances with health-supporting properties. Synthesized solely in the gastrointestinal tract of ruminants, CLA reaches the blood stream and is used by the mammary gland to synthesize milk fat. CLA is embedded in the animal's adipose tissue. There is a large body of research confirming CLA's ability to reduce the risk of atherosclerosis and obesity, and to lower cholesterol levels. When incorporated into the human diet in the amount of 1.5 to 3.5 g, CLA exerts anticarcinogenic effects (it inhibits the development of breast cancer, malignant melanoma, colorectal cancer and lung cancer). CLA prevents

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and alleviates the symptoms of type 2 diabetes; it is a powerful antioxidant and it boosts immunity. The highest quantities of CLA have been noted in the meat of ruminants. The CLA content of ruminant meat has been determined in the range of 10 to 33 mg 100 g^{-1} of fat, being much higher than in pork (2-19 mg) and poultry (3.4 mg). Beef also has the most desirable *n*-6/*n*-3 fatty acid ratio at 6.3:1 in comparison with pork (12.7:1) and poultry (8.3:1). The highest levels of *n*-3 fatty acids can also be found in beef (5-6 g in 100 g fat).

The objective of this study was to present and discuss the most recent findings concerning the fatty acid content of beef and its implications for human health. Source data were gathered and grouped thematically, and an attempt was made to characterize beef and its fatty acid profile.

Key words: fatty acids, CLA, minerals, health-promoting properties of beef.

PROZDROWOTNE WŁAŚCIWOŚCI WOŁOWINY

Abstrakt

Dieta współczesnego człowieka zawiera zbyt dużo kwasów nasyconych (SFA–saturated fatty acid) i wielonienasyconych (PUFA–polly unsaturated fatty acid) typu *n*-6, a zbyt mało typu *n*-3, co jest przyczyną m.in. chorób związanych z układem krążenia, otyłością, a także chorobą nowotworową. Do niedawna tłuszcz zwierzęcy, w tym tłuszcz mięsa, był postrzegany jedynie jako źródło niekorzystnych dla człowieka nasyconych kwasów tłuszczowych powodujących miażdżycę, otyłość i niektóre nowotwory. Tymczasem, jak wykazują badania ostatnich lat, tłuszcze zwierzęce zawierają substancje biologicznie czynne o charakterze prozdrowotnym, a niebezpieczne dla zdrowia człowieka są jedynie niektóre kwasy nasycone (laurynowy C12), mirystynowy (C14) oraz palmitynowy C16), a głównie te, które występują w niewłaściwej proporcji, rodziny kwasów *n*-6 do *n*-3. Mięso wołowe zawiera także znaczne ilości składników mineralnych, zwłaszcza fosforu, potasu, magnezu oraz cynku.

Celem pracy było zebranie najnowszej literatury dotyczącej wpływu kwasów tłuszczowych znajdujących się w mięsie wołowym na zdrowie ludzi w aspekcie jej prozdrowotnych właściwości. W tym celu zgromadzono i pogrupowano tematycznie dostępną na ten temat literaturę oraz dokonano próby opisu charakteryzującego mięso wołowe i zawartych w nim kwasów tłuszczowych.

Jedną z substancji o działaniu prozdrowotnym jest sprzężony kwas linolowy (CLA–conjugated linoleic acid), powstający wyłącznie w przewodzie pokarmowym przeżuwaczy (stąd trafia do krwi, a dalej wykorzystywany jest przez gruczoł mleczny do syntezy tłuszczu mleka oraz wbudowany jest w tkankę tłuszczową zwierzęcia), a szczególnie jego izomery cis-9 trans-11 i trans-9 cis-11. Wiele badań potwierdza jego działanie antymiażdżycowe i przeciwdziałające otyłości, a także ograniczające zawartość cholesterolu. Zawartość CLA od 1,5 do 3,5 g w diecie człowieka ma działanie antynowotworowe (hamuje rozwój raka sutka, czerniaka złośliwego, raka jelita grubego oraz raka płuc). Ponadto CLA jest czynnikiem zapobiegającym i łagodzącym objawy cukrzycy insulinozależnej II typu, ma działanie antyoksydacyjne jako silny przeciwutleniacz, a także wykazuje dodatni wpływ na funkcje układu odpornościowego.

Najwięcej kwasu CLA zawiera mięso zwierząt przeżuwających – od 10 do 33 mg CLA, mięso wieprzowe 2-19 mg CLA, a drobiowe 3,4 mg CLA w 100 g tłuszczu. Mięso wołowe ma również najkorzystniejszy stosunek kwasów *n*-6 do *n*-3, który wynosi 6,3:1, podczas gdy w mięsie wieprzowym 12,7:1, a drobiowym 8,3:1. W mięsie wołowym stwierdzono również najwyższą zawartość kwasów z grupy *n*-3 (od 5 do 6 g w 100 g tłuszczu).

Słowa kluczowe: kwasy tłuszczowe, CLA, składniki mineralne, prozdrowotne właściwości wołowiny.

INTRODUCTION

Beef is a highly valued type of meat around the world, and it ranks second to pork in the global meat consumption structure. The highest beef consumption is noted in developed countries whose inhabitants show a clear preference for beef owing to its high nutritive value and sensory properties. Beef is tender, juicy and characterized by a bright red color and delicate flavor. Beef protein constitutes muscle building material of high biological value, and its flavor attributes are determined by fat content (Barowicz 2007). The availability of beef protein for consumers varies from 70 to 100%, subject to the content of connective tissue. Beef has moderate calorific value and is leaner than mutton and pork. It is a rich source of minerals, in particular phosphorus, potassium, magnesium and zinc (Figure 1). Phosphorus is the key bone-building material, potassium regulates water use in the body, magnesium enhances heart function and zinc improves immunity and contributes to healthy skin (Kowalski et al. 2010). Beef has the highest zinc content among all types of meat. Determined at 3.8 mg/100, its zinc content is two-fold higher than in pork and veal, and 5- to 7-fold higher than in poultry (Barowicz, Brejta 2000, Barowicz 2007).

Beef is also the main source of vitamins B1, B2, B6 (50%) and iron (35%) in human nutrition. The highest levels of vitamin B2 are observed in veal at 0.3 mg 100 g^{-1}, whereas beef contains only insignificantly smaller amounts of this nutrient at 0.2 mg 100 g^{-1}. Beef contains 1.4 mg 100 g^{-1} of vitamin B12, 0.1 mg 100 g^{-1} of vitamin B1 (essential for carbohydrate metabolism and normal function of the nervous system). The highest iron concentrations are noted in beef and veal (around 2.5 mg 100 g^{-1}), and iron levels are 2.5-fold lower in pork and 5-fold lower in poultry. Iron plays a vital role in the human body. Iron deficiency leads to anemia, fatigue, poor concentration, impaired physical and mental activity, and higher susceptibility to infection (Kowalski et al. 2010, Zwierzchowski et al. 2011). Animal products contain easily available heme iron, whereas plants are a source of non-heme iron, which is less readily absorbed by the body. Figure 1 indicates the relevant quantities of other food products that deliver the same amounts of zinc, iron and B vitamins as 100 g of beef (Department of Agriculture 2002).

Unlike pork, beef is not intended solely for processing, and it often consumed in raw (steak tartare) or semi-raw form (rare steak). For this reason, beef cattle have to be healthy, free of parasites and adequately fed during fattening. Nutritional regime is an environmental factor that affects the quality of beef. Fattening intensity could influence beef carcass fatness. Daily gains should fall in the range of 900-1000 g to guarantee a high content of lean meat in the carcass. The meat of young bulls weighing 475--500 kg, fed silage or grass haylage, is lighter in color than the meat of animals whose diets are composed mainly of concentrate. Age at slaughter is also an important factor that affects the quality and cooking suitability

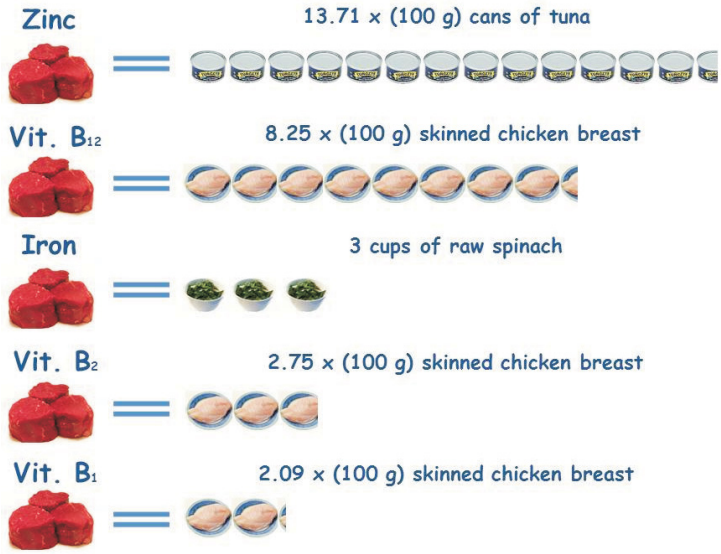

Fig. 1. Zinc, iron and B vitamin concentrations in other food products. (*Agricultural Research Service* 2002).

of beef. Aging leads to higher muscle mass and a decline in meat tenderness (due to an increased diameter of muscle fibers), decreased marbling and lower water-holding capacity. For this reason, attempts are made to lower slaughter age and intensify the fattening regime to increase the final body weights of animals.

OBJECTIVE OF THE STUDY

The objective of this study was to discuss the health benefits of beef for consumers, in particular the role of beef fatty acids in the prevention of atherosclerosis, cancer, heart disease and diabetes.

MATERIALS AND METHODS

This paper overviews the most recent research findings concerning the health-promoting properties of beef. Source materials were gathered and grouped thematically to describe the characteristics of beef and its fatty acid profile.

DISCUSSION

Until recently, animal fat, including meat fat, was regarded solely as a source of saturated fatty acids which are a risk factor for atherosclerosis, obesity and certain types of cancer. Recent studies indicate, however, that animal fats contain biologically active substances that deliver health benefits (STRZETELSKI, STASINIEWICZ 1999, STRZETELSKI et al. 2003), and that adverse health consequences are noted only in respect of some saturated fatty acids (KHOSLA, SUNDRUM 1996) as well as polyunsaturated fatty acids (PUFA) with an unfavorable *n*-6/*n*-3 fatty acid ratio. Beef has a relatively high content of saturated fatty acids and lower levels of unsaturated fatty acids. Recent research indicates, however, that in the group of saturated fatty acids, only lauric acid (C12), myristic acid (C14) and, to a smaller extent, palmitic acid (C16) contribute to the risk of respiratory disease.

Contemporary human diet contains excessive quantities of *n*-6 saturated fatty acids (SFA) and polyunsaturated fatty acids (PUFA), but is deficient in *n*-3 fatty acids. This imbalance could be a cause of respiratory diseases, obesity and cancer (SKRZYPEK 1999). According to LABORDE et al. (2001), every 1000 kcal consumed should deliver a maximum of 11 g SFA, a minimum of 3300 mg *n*-6 PUFA and a minimum of 500 mg *n*-3 PUFA. According to contemporary nutritional standards, a healthy *n*-6/*n*-3 PUFA ratio is 2-4 to 1, whereas in developed countries, the actual ratio is 10-14 to 1 (SIMOPOULOS et al. 1994a, SIMOPOULOS et al. 1994b, SIMOPOULOS 2001).

Table 1

Average fat and cholesterol content of beef cuts (HONIKEL ARNETH 1996)

Cut	Fat content g)	Cholesterol content (mg)
Loin end	2.6	49.0
Sirloin	2.7	51.0
Loin	6.3	48.5
Best ribs	11.3	48.0
Ribs	13.9	66.5

Conjugated linoleic acid (CLA), in particular its cis-9 trans-11 and trans-9 cis-11 isomers, is one of the substances with health-supporting properties (STANTON et al. 1997). Synthesized solely in the gastrointestinal tract of ruminants, CLA reaches the blood stream and is used by the mammary gland to synthesize milk fat. CLA is embedded in the animal's adipose tissue. There is a large body of research confirming CLA's ability to reduce the risk of atherosclerosis and obesity and to lower cholesterol levels (STANTON et al. 1997, PARODI 1999, FRITSCHE, STEINHARD 1997). As demonstrated by LABORDE et al. (2001), when incorporated into the human diet in the amount of 1.5 to

3.5 g, CLA exerts anticarcinogenic effects (it inhibits the development of breast cancer, malignant melanoma, colorectal cancer and lung cancer). According to Ip et al. (2001). CLA has the above properties only when consumed in quantities higher than 3.5 g. CLA prevents and alleviates the symptoms of type 2 diabetes, is a powerful antioxidant and boosts immunity.

The highest quantities of CLA have been noted in milk and fat of ruminants. The CLA content of ruminant meat has been determined in the range of 10 to 33 mg 100 g^{-1} of fat, and it is much higher than in pork (2-19 mg) and poultry (3.4 mg) (Fogerty 1988). Beef also has the most desirable *n*-6/*n*-3 fatty acid ratio at 6.3:1 in comparison with pork (12.7:1) and poultry (8.3:1).

Table 2

Composition of the fatty acid pool (%) in the fat of slaughter animals (Bartnikowska et al. 2002)

Fatty acid	Pork	Beef	Poultry
Saturated (SFA)	37.0-50.6	42.6-57.6	25.2-33.9
Monounsaturated (MUFA)	41.1-51.6	39.5-51.8	43.7-52.
Polyunsaturated (PUFA)	6.6-14.2	2.6-5.5	17.5-26.0
C12:0 + C14 :0	1.2-14.2	2.0-3.7	1.1-2.1
C16:0	23.0-27.0	22.5-26.0	18.0-24.0

Table 3

The effect of selected factors on SFA, PUFA and CLA concentrations in beef

Specification	Fatty acid (% total acids)						Authors
	SFA		PUFA			CLA	
	$C_{16:0}$	$C_{18:0}$	*n*-3	*n*-6	*n*-6/*n*-3		
Breed							
Hereford	20.1	-	3.27	12.67	3.96	0.32	Dymnicka et al. 2004
Charolaise	20.9	-	3.96	16.03	4.06	0.26	
Limousine	20.7	-	2.90	15.23	5.45	0.26	
Feed type							
Maize silage + concentrate	20.7	-	2.96	13.81	4.77	0.30	Dymnicka et al. 2004
Grass haylage + concentrate	20.3	-	3.50	15.81	4.66	0.24	
Green forage	24.3	15.8	-	-	1.32	-	Enser et al. 1998
Concentrate (ground barley, soybean meal + ground barley)	23.2	13.7	-	-	9.20	-	
Meadow grass	22.8	14.7	1.36	3.14	2.33	1.08	French et al. 2000
Concentrate 8 kg + hay 1 kg)	27.4	15.9	0.84	3.21	4.15	0.37	
Grass haylage + concentrate 4 kg	26.6	16.0	0.91	2.96	3.61	0.47	
Green forage	21.7	17.1	2.37	3.46	1.46	0.78	
Grass haylage + concentrate 3 kg	24.1	16.9	1.59	3.50	2.21	0.53	Noci et al. 2005

The highest levels of n-3 fatty acids can also be found in beef (5-6 g in 100 g fat) – Skrzypek 1999.

The fatty acid content of meat fat is affected by breed (Siebert et al. 1998, Zembyashi et al. 1999, Kazala et al. 1999, Laborde et al. 2001), nutrition (Di Luccia et al. 2003) and, as demonstrated by Rule (1994), fat type (subcutaneous, kidney and intramuscular fat). Di Lucia et al. (2003) have observed differences in the concentrations of SFA and UFA subject to the analyzed muscles.

CONCLUSIONS

In comparison with other types of meat, beef is a source of highly digestible proteins with a desirable amino acid composition. Beef contains more B vitamins, minerals with antioxidant properties (Fe, Zn, Cu, Mg, Se) and biologically active substances that deliver health benefits. Beef fat is a source of unsaturated fatty acids and conjugated linoleic acid that prevent and inhibit the development of various diseases. The use of green forage in the dietary regime of ruminants increases the share of *n*-3 PUFA in beef fat, guarantees a healthier *n*-6/*n*-3 PUFA ratio and increases the concentrations of non-enzymatic antioxidants: vitamin E, ascorbic acid and beta-carotene. The incorporation of oilseed plants, plant fats and green forage in cattle's diets is believed to be the most effective method of increasing the concentrations of desirable fatty acids in beef.

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