Meat consumption and its influence on humans' health

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Abstract

Meat consumption has been increasing constantly, not only because of more habitants but increment in per capita consumption is also noticeable. Meat is a good source of highly quality proteins, iron, other nutrients and bioactive substances. At the same time there are some concerns about adverse influence of meat on human's health. The biggest concerns are linked with processed red meat consumption but there is no clear evidence of relationships between unprocessed red meat consumption and certain ailments (cardio vascular disease, cancer). Fish meat consumption is health beneficial due to its fatty acids composition and highly absorbable proteins, but there are also some concerns about the content of methyl mercury in fish meat. According to studies, meat should be consumed in moderation concerning all positive and negative influence of meat on human's health.

Beef meat, consumption, fish meat, pork meat, poultry meat, sheep meat

Introduction

Diet and nutrition are the one of the most important factors influencing human's health, and significant part of human's diet is consisted of meat (Hallstrom et al. 2014). All parts of animal that can be consumed by humans can be named or considered as meat. It means that meat includes both edible carcass and offal. There are differences among species, for an example: hide of beef and lamb is removed but skin of pork and poultry is considered edible and it is part of the meat (Schneller 2009).

The consumption of meat has been increasing constantly especially because the population which belongs to middle class is getting bigger in developing countries (Vranken et al. 2014). The proof for it is information that in Asia meat consumption is 30 times higher than it was in 1960's (Reynolds et al. 2014). The amount of meat that is consumed by person varies a lot in different countries. Countries with higher incomes have bigger meat consumption and in the USA meat contribute with 15% in daily diet, 40% in protein intake and 20% in fat intake. The demand for meat is constantly increasing in developing countries and meat is starting to replace plant foods in consumers' daily diet (Daniel et al. 2010). The consumption of meat have increased by 60% since 1990 due to more populated world but the consumption per capita also increased by 25%. Although, white meat consumption is increasing while bovine, sheep and pig meat consumption is decreasing. The reduction is the fastest with sheep meat consumption and then with pig and bovine meat. There is estimation that poultry meat will take the dominated position of pig meat on the market (Henchion et al. 2014).

Meat can be grouped into three groups: red meat (beef, lamb, veal and pork), white meat (chicken, game and turkey) and processed meat (cured and smoked meats, ham, bacon, sausages, hamburgers, salami and tinned meat) (McAfee et al. 2010). Other types of meat have been also investigated recently which can change traditional meat consumption. One of those meats is foal meat which has been a subject of studies and represents possible good alternative for red meat. The advantages of foal meat are fatty acids composition (higher

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amount of n-3 unsaturated fatty acids) and mineral content (Lorenzo et al. 2014). In vitro meat consumption can also become our reality in not so far future. There is an estimation that in vitro meat production would use only 1% of soil, 4% of water and 50% of energy that is used in farmed beef production. At the same time, it would produce 85% less green house gases than beef meat production (Tucker 2014).

Red meat

The World Cancer Research Fund (WCRF) in 1997 recommended that daily intake of red meat should not be more than 80 g/d (grams per day), including very low amount of processed meat. After 10 years WCRF changed recommendation and lowered the amount of red meat daily intake to 71 g/d (or 500 g per week) and stating that processed meat should not be consumed at all (McAfee et al. 2010).

Many epidemiological studies found relationship between red meat consumption and higher risks for CDV (due to higher amounts of cholesterol and saturated fats) and some cancers. Compounds which have found responsible for this higher risk are fat content of red meat and its fatty acids composition and the fact that during cooking and application of higher temperature some carcinogenic compounds are formed, such as heterocyclic amines (HCAs). The increased risk is influenced also by type of meat, rearing, processing of meat and preparation. Red meat (both fatty and lean red meat) and processed meat consumption can be connected with higher chance for obesity. At the same time, it should be noted that many health benefits can be linked with the consumption of red meat (Daniel et al. 2010; McAfee et al. 2010; Wang et al. 2014 and Song et al. 2014).

On the other side, the fact is that in the last ten years the consumption of red meat in the Great Britain decreased significantly but at the same time the prevalence of colon cancer increased (McAfee et al. 2010). If it is considered that 85 g is the amount of an average lean red meat portion then it contains these daily recommended amounts: 8% calories, 50% proteins, 45-62% zinc, 91% B12, 52% selenium, 21% phosphorus, 31-36% niacin, 31% B6, 12-27% iron, 13-15% riboflavin (McNeill 2014).

Consumers' preferences have been changing and consumers are more informed about possible bad effect of fatty red meat and they are changing their diet according to it. Meat industry is also adapting to new consumers' preferences and that's why red meat is produced much leaner and with less fat content than ten years ago due to different animal production, animals' diet and butchery techniques. As a consequence lean beef meat has lower amount of fat content (saturated fatty acids, monounsaturated fatty acids and polyunsaturated fatty acids) and cholesterol level (McNeill 2014).

The composition of beef meat

Only 100 g of beef/veal meat contains 50% of daily recommended proteins, 100% of niacin, 100% of B12 and 50% of zinc (Williams 2007). The composition of beef and veal meat is shown in Table 1.

The profile of fatty acids composition of lean beef meat is following: 54% monounsaturated and up to 5% polyunsaturated fatty acids. The ration between polyunsaturated and saturated fatty acids is 0.1; while for very lean beef meat it is from 0.5 to 0.7. Beef meat is a good source of conjugated linoleic fatty acid (CLA) and vaccenic fatty acid (trans-11 18:1) which has a protective role against coronary heart diseases. Vaccenic fatty acid in beef meat differ from industrial vaccenic fatty acid. In comparison with refined carbohydrates when they are changed in diet by lean beef meat it comes to the improvement of blood pressure and vascular reactivity (McNeill 2014 and Scollan et al. 2014). The main fatty acids in beef meat are myristic (C14:0), palmitic (C16:0) and stearic (C18:0) acid. Totally 30% of saturated fatty acids are composed of stearic acid. Studies showed link between myristic and palmitic acids intake and higher risk for coronary heart diseases, but

stearic acid has very little influence on cholesterol level in blood (McAfee et al. 2010 and McNeill 2014). There has been studies trying to change and improve beef meat nutrition by different feeding and it was found that fatty acids composition is more influenced by animal diet than with genetic predisposition. Experimentation with different diets for beef showed that even beef meat can achieve 40 mg·100 g^{-1} of eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) that could be labeled as 'a source of' or 'high in' n−3 polyunsaturated fatty acids (PUFA) (Scollan et al. 2014).

Table 1. The composition of beef and veal meat (Williams 2007)

	Beef	Veal	Daily recommended intake [RDI]
Moisture [g]	73,1	74,8	
Protein [g]	23,2	24,8	46 – 64
Fat [g]	2,8	1,5	
Energy [kJ]	498	477	6.5 – 15.8 MJ
Cholesterol [mg]	50	51	
Vitamin content [per 100 g] in beef and veal meat			
Thiamin [mg]	0.04	0.06	1.1 – 1.2
Riboflavin [mg]	0.18	0.20	1.1 – 1.6
Niacin [mg]	5.0	16.0	14 – 16
Vitamin B6 [mg]	0.52	0.8	1.3 – 1.7
Vitamin B12 [µg]	2.5	1.6	2.4
Pantothenic acid [µg]	0.35	1.50	4 – 6
Vitamin A [µg]	< 5	< 5	700 – 900
Beta-carotene [µg]	10	< 5	700 – 900
Alpha tocopherol [mg]	0.63	0.50	7 – 10
Mineral content [per 100g] in beef and veal meat			
Sodium [mg]	51	51	460 – 920
Potassium [mg]	363	362	2800 – 3800
Calcium [mg]	4.5	6.5	1000 – 1300
Iron [mg]	1.8	1.1	8 – 18
Zinc [mg]	4.6	4.2	8 – 14
Magnesium [mg]	25	26	310 – 420
Phosphorus [mg]	215	260	1000
Copper [mg]	0.12	0.08	1.2 – 1.7
Selenium [µg]	17	< 10	60 – 70

The composition of sheep meat

Lamb meat in comparison with beef meat has higher content of linoleic, arachidonic, linolenic, EPA and DHA acids contents. For human health it is of special interest the content of conjugated linoleic acid, especially intramuscular *c*9t11CLA, which varies between 0.2 – 1 g·100 g^{-1} in lamb and beef meat (Raes et al. 2004). Studies with animals showed that CLA possesses health benefits in the way that lowers body fat, improves insulin sensitivity, improves lipid profiles and decreases risk of atherosclerosis. Though, human's studies have been showing opposite results about health benefits of CLA in human's diet (Temple et al. 2012). The ratio between polyunsaturated and saturated fatty acids (P/S) in sheep meat is lower, same as in all ruminants due to fact that they hydrogenate unsaturated fats in their diet, oppositely from pork that stores dietary unsaturated fats unchanged (Enser et al. 1998). The composition of lamb and mutton meat is shown in Table 2.

Table 2. The composition of lamb and mutton meat (Williams 2007)

	Lamb	Mutton	Daily recommended intake [RDI]
Moisture [g]	72.9	73.2	
Protein [g]	21.9	21.5	46 – 64
Fat [g]	4.7	4.0	
Energy [kJ]	546	514	6.5 – 15.8 MJ
Cholesterol [mg]	66	66	
Vitamin content [per 100 g] in lamb and mutton meat			
Thiamin [mg]	0.12	0.16	1,1 – 1,2
Riboflavin [mg]	0.23	0.25	1,1 – 1,6
Niacin [mg]	5.2	8.0	14 – 16
Vitamin B6 [mg]	0.10	0.8	1.3 – 1.7
Vitamin B12 [µg]	0.96	2.8	2.4
Pantothenic acid [µg]	0.74	1.33	4 – 6
Vitamin A [µg]	8.6	7.8	700 – 900
Beta-carotene [µg]	< 5	< 5	700 – 900
Alpha tocopherol [mg]	0.44	0.20	7 – 10
Mineral content [per 100 g] in lamb and mutton meat			
Sodium [mg]	69	71	460 – 920
Potassium [mg]	344	365	2800 – 3800
Calcium [mg]	7.2	6.6	1000 – 1300
Iron [mg]	2.0	3.3	8 – 18
Zinc [mg]	4.5	3.9	8 – 14
Magnesium [mg]	28	28	310 – 420
Phosphorus [mg]	194	290	1000
Copper [mg]	0.12	0.22	1.2 – 1.7
Selenium [µg]	14	< 10	60 – 70

The composition of pork meat

The main fatty acids in pig meat are oleic (C18:1), linoleic (C18:2), palmitic (C16:0), palmitoleic (C16:1) and stearic (C18:0). With different diet, including linseed, fatty acids composition of pig meat can be changed and the amount of n-3 polyunsaturated fatty acids can be increased. The increase of PUFA in pig meat is beneficial for consumers because they have anti-inflammatory, anti-thrombogenic and hypotriglyceridemic properties. They are also lowering the risk for some cancers (colon, breast and prostate) and cardiovascular diseases (Okanovic et al. 2012).

Amino acid composition of pork meat is well balanced and it corresponds to nutritional requirements for humans. Cholesterols, mineral and vitamin contents in pork meat are almost at the same level as in other species but iron content in pork meat is lower in comparison with meat of ruminants. Oleic acid is the major fatty acid in pork meat (35 – 45% of total fatty acids). More unsaturated fatty acids are stored in muscles than in fat tissues (Ledward et al. 2009). The composition of pork meat is shown in Table 3.

Poultry meat

It is widely accepted that poultry meat is very good source of high quality proteins, B vitamins and minerals. Poultry is considered much leaner meat than red meat and that is the one of reasons for increase in poultry meat production worldwide. Poultry meat is leaner because almost all fat is subcutaneous, there is no marbling and there is only

Table 3. Pork fillet composition (Ledward et al. 2009)

	Pork fillet [per 100 g]
Energy [kJ]	475
Water [g]	74.4
Proteins [g]	21
Lipids [g]	3.2
Cholesterol [mg]	65
Iron [mg]	1.2
Niacin [mg]	4.3
Vitamin E [mg]	0.1
Thiamin [mg]	1
Vitamin B6 [mg]	0.45
Vitamin B12 [µg]	0.7
Folate [µg]	4
Sodium [mg]	125

minimal intramuscular fat in chicken breast meat (Shabtai 2002). Nutritional value and composition of different raw poultry meats are shown in Table 4.

Fish meat

The main source in human's diet of n-3 PUFA is fish meat. Some plants such as flax contain higher amounts of omega-3 fatty acids but they don't contain long chain omega-3 fatty acids like docosahexaenoic acid (DHA) (Rahmawaty et al. 2014). The meat is main source of amino acids in humans' diet especially in western countries. Availability of amino acids in meat is influenced by many factors such as type of meat, cooking conditions, fat content and carbohydrates content. Amino acids in fish meat are better absorbed by human organism in comparison with amino acids from other types of meat. The presence of n-3 long chain polyunsaturated fatty acids in fish meat also helps better absorption of amino acids due to their support for gastric emptying (Rossary et al. 2014).

Table 4. Nutritional value and composition of different raw poultry meats (Shabtai 2002)

Source of meat			Water	Protein	Fat	Ash	Iron	Calories
Species	Meat	Skin	[%]	[%]	[%]	[%]	[mg]	[kcal]
Chicken	white	+	68.6	20.3	11.1	0.86	0.8	186
		-	74.9	23.2	1.6	0.98	0.7	114
	dark	+	65.4	16.7	18.3	0.76	1.0	237
		-	75.9	20.1	4.3	0.94	1.0	125
Turkey	white	+	69.8	21.6	7.4	0.90	1.2	159
		-	73.8	23.5	1.6	1.00	1.2	115
	dark	+	71.1	18.9	8.8	0.86	1.7	160
		-	74.5	20.1	4.4	0.93	1.7	125
Duck	all	+	48.5	11.5	39.3	0.68	1.4	400

It was demonstrated by studies that n-3 PUFA, eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) promote anti-tumor immunity, inhibit cancer initiation, tumor angiogenesis and metastasis. It means that these fatty acids are included in mechanisms of cell proliferation impairment and cell death. Experimental studies (in vitro and animal studies) showed that DHA and EPA can increase apoptosis rate in different cancer cells including breast, colon, lung, prostate, lymphoma, leukemic, hepatic, pancreatic and larynx. Intake of n-3 PUFA (EPA 100 mg·day^{-1} and DHA 400 mg·day^{-1} during 2 years) showed an increase in apoptosis of colonic mucosa in humans. The supplementation of EPA (2 g·day^{-1}) resulted in significant increase of apoptosis in normal colonic mucosa in people with colorectal adenomas history (Calvello and Serini 2010).

Comparisons between compositions of different lean muscle tissues are shown in Table 5. Lipid content of meat varies during year, especially in fatty fish, thus lipid content in mackerel can vary from 5.1% to 22.6% (Fennema 1996).

Table 5. Lean muscle tissue composition (Fennema 1996)

	Composition [%]			
	Water	Protein	Lipid	Ash
Beef	70 - 73	20 - 22	4 - 8	1
Pork	68 - 70	19 - 20	9 - 11	1.4
Chicken	73.7	20 - 23	4.7	1
Lamb	73	20	5 - 6	1.6
Cod	81.2	17.6	0.3	1.2
Salmon	64	20 - 22	13 - 15	1.3

Fatty acids composition is one of the main properties of fish meat which includes fish in healthy diet. That is the reason why it is very important to collect information how different type of processing influence fish fatty acids composition. There is a difference between fatty acids composition in raw fish and cooked fish meat. Frying affects fish meat fatty acids composition the most in the way that comes to an increase of n-6 SAFA (saturated fatty acids), MUFA (monounsaturated fatty acids) and PUFA (polyunsaturated fatty acids), while n-3:n-6 ratio is lowered (Neff et al. 2014).

Disadvantages of meat consumption

Polyunsaturated/saturated ratio (P/S)

One of disadvantages of meat consumption is its low polyunsaturated/saturated (P/S) ratio. It is considered that P/S ration lower than 0.45 is indication for less healthy food. P/S rations of beef, lamb and pork meat are 0.11; 0.15; 0.58; respectively. Although many studies showed that P/S ratio can be significantly influenced by animal feeding. Additionally, n6/n3 PUFA ratio in pork meat is 7.2 and recommendation for healthy food is < 4.0 (Enser et al. 1998). Diet rich in n6 fatty acids disrupts the production of long chain omega-3 fatty acids and formation of anti-inflammatory products such as prostaglandins (Wolf 2010).

Higher protein consumption

High protein diet is very often linked with higher risk for osteoporosis or bone fractures, but with higher meat consumption intake of phosphorous is also evaluated which reduces urinary calcium. Higher meat consumption can have very little influence on calcium balance in organism. This is supported by the study of Roughead et al. (2003) where was not found adverse effects of meat consumption on calcium retention and bone metabolism among postmenopausal women (Table 6).

Unprocessed versus processed red meat

There is a necessity for distinguishing unprocessed red meat and processed red meat. What was shown in the study of Bellavia et al. (2014) where was found that less survival rate was connected with higher red meat consumption (> 300 $g \cdot w^{-1}$) but only in case when higher amount of processed red meat was included in diet. The study consisted of monitoring 75 000 people during 15 years (Table 6). According to Abete et al. (2014) higher consumption of processed meat is related with higher risk of any-cause mortality and cardio vascular diseases, while higher red meat consumption is only weakly associated with cardio vascular diseases (Table 6). Maybe there is also some kind of relationship with negative red meat consumption and region because the majority of studies which link higher red meat consumption with health risks are from North America and European regions, while studies done in Asia haven't found this relationship (Abete et al. 2014).

Similar results were obtained in the research of Lajous et al. (2014) where was found that higher consumption of processed red meat is in relationship with high blood sugar, because of high sodium content in these kind of products. Researchers also didn't find connection between higher blood pressure and consumption of unprocessed red meat (Table 6).

Table 6. Studies about influence of meat consumption on humans' health

Reference and location	Number of participants and period of investigation	Type of meat (affecting amount)	Examined issue	Findings
Rossary et al. 2014 Southampton. United Kingdom	123 pregnant women (from20 weeks pregnancy until birth)	Salmon (300 g)	Plasma amino acid analysis	↓No changing in umbilical cord plasma. ↑Partly prevents the decline of amino acids in plasma.
Abete et al. 2014 UK. USA. Europe. Australia. Japan China	13 cohort studies; 1 674 272 participants (from 5 to 28 years)	Red. white and processed meat consumption	CVD IHD mortality	↓18% higher risk of CVD mortality (processed meat). ↓16% higher risk of CVD mortality (red meat). ↓22% higher risk of any cause of mortality. ↑No connections with total meat and white meat consumption with mortality. ↑No associations between any type of meat and IHD mortality.
Chen et al. 2014 Hong Kong	1 252; 24 hours dietaries questionnaires	Seafood (450 g)	Methyl mercury influence on children IQ	↓11% of participants were exposed to 1.6 $\mu g \cdot kg^{-1}$ of MeHg ↑health benefits of eating fish overcome the risk for decreased children's IQ related with MeHg content in seafood.
Karimi et al. 2014 USA	996; screening questionnaires	Seafood	Total mercury content in blood (THg)	↓Higher Hg content, consumers eating tuna, swordfish, shark and marlin two times per week. ↑no link between light canned tuna and higher Hg content in blood.
Pham et al. 2014 Japan	Six cohort studies and 13 case–control studies	Total meat consumption (TMC)	Colorectal cancer	↓Red meat and processed meat consumption moderate risk for colon cancer. ↑No clear evidence of connection with TMC and colorectal cancer. ↑Higher poultry consumption – decreased risk for rectal cancer.
Lajous et al. 2014 France	44 616 disease free French women (during 15 years)	Red meat and processed red meat	Hypertension	↓Processed red meat consumption is associated with hypertension. ↑Unprocessed red meat consumption is not associated with hypertension.
Bellavia et al. 2014 Sweden	74 645 men and women (during 15 years)	Red meat and processed red meat	Association with survival/longevity	↓Total red meat consumption (including processed red meat) is associated with shorter survival. ↑Nonprocessed red meat consumption is not associated with shorter survival.
Ascherio et al. 1995 USA	44 895 men aging from 40 to 70 years (during 6 years)	Fish meat consumption	Relationship with coronary disease	↓There was not found relationship with higher fish intake and reduction of coronary disease.
Daviglus et al. 1997 USA	1 822 men aging from 40 to 55 years. (during 31 years)	Fish meat consumption	Relationship with coronary disease	↑There was found relationship with higher fish meat consumption and smaller prevalence of cardiovascular disease.
Roughead et al. 2003 USA	15 postmenopausal women aging from 50 to 70 years (monitored during 28 days)	High protein diet	Osteoporosis. calcium retention	↑There was no adverse affect of meat consumption on bone metabolism.
Choi et al. 2004 USA	47 150 men without history of gout aging 40 to 75 years (during 12 years)	Meat and seafood	Gout prevalence	↓Higher consumption of meat and seafood leads to increased risk of gout.

*↑ indicating positive health influence; ↓ indicating negative health influence

In the study carried out by Sinha et al. (2009) it was found that people (both women and men) with bigger meat consumption had higher risk for cardio vascular diseases (CVD) and cancer. In the same study lower risk for CVD was associated with white meat consumption than for red meat consumption.

Cancer prevalence concerns

Pham et al. (2014) stated in their review that it is not possible to find clear connection with total meat consumption and higher risk for colorectal cancer but they found linkage between red meat and processed meat consumption with moderate risk for colon cancer. They also found relationship between decreased risk for rectal cancer and higher poultry meat consumption (Table 6.). Oppositely, higher consumption of red meat is according to some studies related to higher incidence of some cancers and cardiovascular diseases (Hallstrom et al. 2014).

N-nitroso compounds, heterocyclic amines and polycyclic aromatic hydrocarbons

The presence of N-nitroso compounds (NOC), heterocyclic amines (HCA) and polycyclic aromatic hydrocarbons (PAH) in red meat are linking it to higher risks for some cancers. NOC are formed when red meat is processed. Carcinogens HCA and PAH are produced in red meat when it is cooked on high temperatures or on open flame. Heme iron in red meat supports the production of NOC, DNA damage and it can also catalyse the formation of cytotoxic and genotoxic aldehydes (Pham et al. 2014).

Salt content in meat

Higher salt intake is responsible for higher prevalence of high blood pressure. Meat contains higher amount of salt than plant food but unprocessed meat contains only 1.2 $g \cdot kg^{-1}$ of salt which is far away from recommended upper daily intake of salt (6 $g \cdot day^{-1}$). Although, processed meat, same as other processed food, contains much higher salt content and 75% of exceeded salt intake comes from processed food (9 – 12 $g \cdot day^{-1}$) (Sung Kyu Ha 2014).

Gout

Higher meat consumption long has been thought that it is related with higher incidence of gout. This statement is in accordance with the study of Choi et al. (2004) which included 47 500 men, without history of gout, aging 40 to 75 years. The study was conducted in the USA and health conditions of participants were monitored during 12 years. It was found that higher consumption of meat and seafood leads to increase risk of gout (Table 6.).

Methyl mercury concern

The consumption of fish meat and seafood varies and one of the highest consumption regions is Hong Kong, where consumption is between 450 g to 1500 $g \cdot week^{-1}$. Some results are pointing out that 700 $g \cdot week^{-1}$ seafood consumption overweighs beneficial health properties of seafood consumption due to high methyl mercury (MeHg) content especially in certain fish species such as large predatory fish like shark, swordfish, marlin, orange rough, pike, tilefish, king mackerel and some tuna species. Provisional tolerable weekly intake (PTWI) of MeHg is 1.6 $\mu g \cdot kg^{-1}$ according to JECFA (The Joint FAO/WHO Expert Committee on Food Additives). There are special concerns about pregnant women seafood consumption because methyl mercury can adversely affect foetal brain and nervous system development. Recommended seafood consumption in the USA is 330 $g \cdot week^{-1}$; in Australia and New Zealand it is 300 to 450 $g \cdot week^{-1}$ (Chen et al. 2014). Women who are planning to become pregnant, pregnant women, nursing mother and children should not consume these fish species or they should significantly reduce the consumption of them (Insel et al. 2006).

In the study of Chen et al. (2014) which included 1 252 women of childbearing age was found that 11% of participants were exposed to higher MeHg amounts (>1.6 $\mu g \cdot kg^{-1}$). In their study they tried to find link between lower IQ results of children and mothers' fish consumption but they stated that health benefits of including fish in diet overcomes potential risks of MeHg content in seafood (Table 6).

People are exposed to higher concentrations of mercury (Hg) in their diet mainly because of increase seafood consumption. Hg negatively influences human's health due to neurodevelopment effect, risk for cardiovascular diseases and it also negatively affects immune system. Freshwater fish and sea mammals contain the biggest amount of Hg. It was found that women of childbearing age that lived along coastal region in the USA has higher Hg content in blood compared with women not living in coastal regions. People who consumed tuna at least twice per week had higher Hg concentrations in blood (6.30 $\mu g \cdot L^{-1}$) than people who consumed tuna only a few times per year. Greater level of Hg in blood was found among persons who consumed swordfish, shark or marlin weekly (9.47 $\mu g \cdot L^{-1}$) (Table 6). On the contrary there was not found relationship between canned light tuna consumption and higher Hg concentrations in blood. Totally 22% of participants who consumed seafood twice per week (what is recommended by many health organizations such as American Heart Association) had higher Hg concentrations in blood. At the same time there are some opposite results and other studies did not link fish consumption with high Hg content in blood. Fish species with lowest Hg content are salmon, cod, tilapia, sole, haddock and shrimp. Future studies should show how people are affected with Hg concentrations in seafood and does that attribute of seafood counteract health benefits of including seafood more often in diet (Karimi et al. 2014).

Adverse affect on environment

One more disadvantage of red meat consumption is the emission of greenhouse gases which formation is nine times higher for the production of meat-centric meal than to plant based meal (Reynolds et al. 2014). Meat production is the most devastating food production for environment and it is constantly increasing due to predictions that until 2030 meat production will be increased by 72% in comparison with the production in 2000 (Tucker 2014).

Advantages of meat consumption

Bioavailability of meat nutrients

Red meat is a good source of highly quality proteins: iron, zinc, selenium, phosphorus, vitamin D, niacin, riboflavin, vitamin B_6 and B_{12} (Hallstrom et al. 2014 and McNeill 2014) (Williams 2007). Too much lowering the consumption of red meat can lead to iron and protein deficiencies (Tucker 2014). As an example, in Swedish diet red meat contributes in daily diet in these proportions: 11% of energy, 25% of proteins, 19% of total fat, 19% of saturated fat, 21% of iron, 30% of zinc. It means that lowering red meat consumption would affect the most iron and zinc intake (Hallstrom et al. 2014). In comparison with proteins in beans and whole wheat, which are 78% and 86% digestible respectively, proteins in meat are 94% digestible and they contain all essential amino acids. Beef and lamb meat is a great source of iron and zinc. Iron in meat is in haem-iron form which is highly absorbable; also zinc from meat is more absorbable than from plant food. Selenium is also present in higher amounts in red meat, and sodium level is low in lean meat (Williams 2007). Beef and lamb meat have n6/n3 PUFA ratio which fulfils recommendation for health food. < 4.0 (beef: 2.1; lamb: 1.3) (Enser et al. 1997).

Melatonin content in meat

Melatonin is one more substances normally occurring in meat. Melatonin is free radical scavenger, it has antioxidant properties and it protects organism against oxidative stress.

It is beneficial for neurodegenerative diseases, heart disease and diabetes. Another benefit of melatonin is that activates brown adipose tissue and transformed energy stored in fat into heat, it improves metabolisms of lipid and glucose and that is the reason why it is connected with weight loss in some studies (Tan et al. 2014).

Choline content in meat

Meat is one of the best sources of choline. Choline is an essential nutrient and its role in human organism is complex. The main role of choline is its participation in synthesis of phospholipids and it plays the important part in foetus' brain development. Average choline content in meat is 430 mg·100g^{-1} and adequate intake of choline is 425 mg·day^{-1} for women and 550 mg·day^{-1} for men (Zeisel and Costa 2009).

Bioactive compounds in meat

Meat contains substances that cannot be called nutrients but they have bioactive properties and examples of such bioactive components in meat are taurine, carnosine, coenzyme Q10 and creatine. Taurine is health beneficial for infants and some groups of older people. It was also shown that taurine affects positively exercise-induced muscle injury. Carnosine and coenzyme Q10 are antioxidants and they have anti-aging properties. Creatine can increase muscle performance if it is taken as ordinary supplement during certain time-period. Lamb and beef meet are good sources of these bioactive components but amounts in meat are much lower than amounts which could be provided by specially produced diet supplementations (Purchas et al. 2004).

The biggest source of L-carnitine is red meat. L-carnitine is a very important small molecule (derived from lysine) in metabolism of fatty acids. An average recommended daily dose of L-carnitine for human weighing 70 kg is 70 mg. It means that it is necessary to eat 100 g of meat daily to meet this recommendation, mainly red meat because L-carnitine content in fish meat is much lower and the consumption of red meat in the majority of countries is much lower in comparison with red meat consumption (Rigault et al. 2008).

Health benefits of fish meat

The consumption of fish meat has positive effect on humans' health because it was found by some epidemiological studies and two case control studies that higher consumption of fish meat leads to smaller prevalence of coronary disease. This statement was confirmed by research of Daviglus et al. (1997) in which 1822 men participated (aging 40 – 55) and were followed during 31 years (Daviglus et al. 1997) (Table 6). On the other side, there are studies which confirmed opposite results, such as the research conducted among men in the USA (44 895 men without history of coronary disease, followed during 6 years) where was found that the increase of fish consumption from 1 to 2 servings per week to 5 to 6 servings per week didn't influence prevalence of coronary disease among participated men (Table 6) (Ascherio et al. 1995).

The research of Rossary et al. (2014) showed that salmon consumption (two portions per week: one portion 150 g) partially stops the decrease of four main amino acids in pregnant women but it doesn't affect umbilical cord plasma amino acids concentrations (Table 6).

Fish meat contains higher amounts of proteins, vitamin D and selenium. Selenium is very important micronutrient due to its involvement in the reduction of hydrogen peroxide and in that way protects cells from oxidative damage. Selenium is also part of selenoproteins which are important in thyroid metabolisms. It is important to emphasize that higher intake of selenium is toxic and daily recommended dose is 55 μg·day^{-1}. The safe upper intake of selenium is 400 μg·day^{-1} in the USA and 300 μg·day^{-1} in Europe. Exceeding upper intake recommended dose of selenium can lead to garlic odour on the breath, gastrointestinal

disorders, hair loss, sloughing of nails, fatigue, irritability and neurological damage. Mackerel and tuna have the greatest amount of selenium 0.6 $\mu g \cdot g^{-1}$ but higher amounts are also found in sardines, cockle, clam, prawn, shrimp and mussels. There is relationship between fat content and present selenium amount in fish; lean fish (cod, gilthead, monkfish, sea bass, sole, turbot, whiting) have lower content of selenium compared with fatty fish. Fresh water fish have the lowest selenium content among seafood. There is a different bioavailability of selenium in different fish species or even within same species due to different fish diet or feeding. Probably due to different selenium bioavailability there are opposite results from studies where some found increase of selenium content in blood plasma after inclusion of more fish in diet and on the contrary it was found that fish consumption didn't affect significantly selenium content in blood plasma. There was also found relationship between cadmium concentrations and selenium concentrations. Cadmium content is lower in the presence of higher selenium content. This finding supports the protective role of selenium against toxicity of cadmium (Marval-Leon et al. 2014).

Meat organs

All meat organs are rich in vitamin B12 except brain that is not good source of vitamins and minerals and the level of cholesterol is the highest in brain. Liver is good source of iron, zinc, riboflavin, niacin, retinol and folate. Retinol amount in liver is very high that it is not recommended to consume bigger amounts of liver during pregnancy. Kidneys are good source of proteins, thiamine, riboflavin, iron and folate. There is some iron and zinc in heart but not so much as in liver and kidneys. All organ meats contain higher amounts of cholesterol (Williams 2007).

Conclusions

Human's health is well influenced by nutritional composition of diet. Meat consumption has a big influence on human's health due to the fact that daily meat intake makes bigger portion of human's diet. Additionally, meat consumption has been increasing constantly not only because of world population growth but also due to increase meat consumption per capita.

There is a constant concern about health effects of red meat, especially processed red meat. According to studies it could be concluded that adverse effects on health can be connected only with processed red meat but there is no clear relationship with unprocessed red meat consumption and some ailments (CVD, cancers). Red meat is also good source of high quality proteins, iron and other minerals, vitamins and substances that cannot be called nutrients but they have bioactive properties.

Fish meat consumption is connected with smaller prevalence of coronary disease due to its beneficial fatty acids composition. On the contrary, there are some concerns about methyl mercury content in fish meat and its negative effects on human's health, but some studies stated that health benefits of fish meat consumption overweigh possible higher methyl mercury content in some fish species.

Concerning health benefits and health potential hazards of meat consumption, meat should be included in human's diet with moderation and variety. Further studies are necessary to try to make clear distinguish between different types of meat, especially processed meat products, and their influence on human's health.

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