Phytoestrogens in Animal Origin Foods

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Abstract

Phytoestrogens are a group of polyphenolic plant metabolites that can induce biological responses. Their bioactivity is based on their similarity to 17ß-estradiol and their ability to bind to the ß-estrogen receptor. Reliable information on the phytoestrogen content in foods is required to assess dietary exposure and disease risk in epidemiological studies. However, existing analyses have focused on only one class of these compounds in plant-based foods, and there is only little information on foods of animal origin, leading to an underestimation of intake. Although epidemiological data are inconclusive, phytoestrogens are considered to be beneficial for a variety of conditions. To investigate the biological effects of these compounds and to assess the exposure of larger cohorts or the general public, reliable data on the phytoestrogen content of food is necessary. The analysis of phytoestrogens in food is done by using automated solid-phase extraction and liquid chromatography-tandem mass spectrometry.

Keywords: Phytoestrogens, different classes, foods of animal origin, mechanism of action, analysis

Introduction

Phytoestrogens, secondary plant metabolites, which are structurally or functionally similar to 17ß-estradiol, have received increasing attention for their potentially beneficial effects as estrogen agonists or anti-estrogens in health and disease. Their name comes from phyto = plant and estrogen = estrus (period of fertility for female mammals) + gen = to generate. Their possible effects have been implicated in the etiology of hormone-dependent cancers,cardiovascular diseases, osteoporosis, menopausal symptoms male infertility, obesity and type-2 diabetes. Evidence that these compounds are biologically active even at low levels in humans comes from interactions between phytoestrogens and gene variants of the estrogen receptor (ESR1 and NR1I2), sex-hormone binding globulin (SHBG), and probably aromatase (CYP19). However, these compounds can act as either estrogens or anti-estrogens,

Phytoestrogens were first observed in 1926 but it was unknown if they could have any effect in human or animal metabolism. In the 1940s it was noticed for the first time that red clover (a phytoestrogens-rich plant) pastures had effects on the fertility of grazing sheep. The key structural elements crucial for the estradiol-like effects are:

* The phenolic ring that is indispensable for binding to estrogen receptors (ERs).
* The ring of isoflavones mimicking a ring of estrogens at the receptors binding site.
* Low molecular weight similar to estrogens (MW=272).
* Distance between two hydroxyl groups at the isoflavones nucleus similar to that occurring in estradiol.
* Optimal hydroxylation pattern.

Classes of phytoestrogens

The major classes of phytoestrogens are isoflavones, lignans, and coumestans. In plants, they occur in general as glycosides, which are deconjugated by intestinal glucosidases to release the aglycones. The aglycones can then be further metabolized by the intestinal microflora into hormone-like compounds with weak estrogenic activity. Lignans can be converted into the mammalian lignans enterodiol and enterolactone, whereas the isoflavones daidzein can be converted into O-desmethylangolensin (O-DMA) and equol. Phytoestrogens are mainly excreted in urine, but they have also been found in human and cow's milk. Phytoestrogens cannot be considered as nutrients given that the lack of these in diet doesn't produce any characteristic deficiency syndrome, nor do they

Table-1. Phytoestrogen content in selected foods of animal origin with soy-based comparisons (ug/100 g of wet weight)

Food	Phytoestrogens	Isoflavones	Lignans	Coumestrol	Equol	Enterolactone
Milk						
Semi-skimmed	8	4	1	< 1	1	3
Skimmed	20	14	1	< 1	1	3
Whole	12	6	1	< 1	1	4
Dried skimmed	58	5	8	1	8	37
Soy, unsweetened	6,028	6,018	9	1	--	--
Baby formula	59	19	16	1	5	19
Soy infant formula	19,221	19,211	10	< 1	--	--
Cheese						
Cheddar (Canadian)	36	10	2	1	14	10
Cheddar (English)	28	7	1	< 1	6	13
Cheddar (reduced fat)	62	14	17	2	8	22
Mozzarella	24	4	6	< 1	6	6
Parmesan	27	6	5	1	4	11
Cottage	11	2	2	< 1	1	7
Butter						
Brand 1, salted	13	10	2	< 1	--	--
Brand 1, unsalted	11	9	1	< 1	--	--
Ice cream						
Chocolate	36	20	9	1	1	5
Dairy	16	7	3	< 1	2	4
Soy	13,494	13,488	5	1	--	--
Barn-kept hens	18	8	2	--	4	3
Caged hens	12	6	3	< 1	2	1
Free-range hens	11	6	3	< 1	1	1
Meat and fish						
Beef, roast (fat)	19	3	16	1	--	--
Beef, roast (lean only)	7	1	6	< 1	--	--
Chicken breast, roast	6	4	2	< 1	--	--
Chicken dark meat, roast	4	2	1	--	--	--
Lamb, roast (lean only)	5	1	4	< 1	--	< 1
Pork, roast (lean only)	4	1	3	< 1	--	--
Soy-based burger	4,430	4,410	19	1	--	--
Salmon	4	3	1	--	--	--
Prawns, frozen	8	3	4	1	--	--
Tuna, canned	6	5	< 1	< 1	--	--

participate in any essential biological function.

Plants containing phytoestrogen

Phytoestrogen content varies in different foods, and may vary significantly within the same group of foods (e.g. soy beverages, tofu) depending on processing mechanisms and type of soy bean used. Legumes (in particular soybeans), whole grain cereals, and some seeds are high in phytoestrogen. A more comprehensive list of foods known to contain phytoestrogens includes: soy beans, tofu, tempeh, soy beverages, linseed (flax), sesame seeds, wheat, berries, oats, barley, dried beans, lentils, rice, alfalfa, mung beans, apples, carrots, pomegranates, wheat germ, ricebran, soy linseed bread, ginseng, bourbon and beer, fennel and anise.

Phytoestrogen content of foods of animal origin

A British study analyzed the phytoestrogen content of animal-sourced foods and found a range similar to many vegetables. They pointed out that for cheese, the phytoestrogen content was quite variable, but there was no clear link between the type of cheese and phytoestrogen content. Eggs had a lower phytoestrogen content than milk products, and most phytoestrogens (mainly isoflavones) were found in egg yolks. The researchers noted that the phytoestrogen content was considerably higher in soy-based foods. For example, soy milk and yogurt contained almost 500 times more phytoestrogens than their milk-based counterparts. They suggested that the phytoestrogens found in animal-sourced foods may have been derived from animal feeds and pastures, especially those containing clover and other legumes.

Mechanism of action of phytoestrogens

The chemical structure of phytoestrogens is similar to estrogen, and they may act as mimics of estrogen. On the other hand, phytoestrogens also have effects that are different from those of estrogen.

Working as estrogen mimics, phytoestrogens may either have the same effects as estrogen or block estrogen's effects. The effect which the phytoestrogen produces can depend on the dose of the phytoestrogen. The phytoestrogen can act like estrogen at low doses but block estrogen at high doses. Estrogen activates a family of proteins called estrogen receptors. Recent studies have shown that phytoestrogens interact more with some members of the estrogen receptor family, but more information is needed about how these receptors work. Finally, phytoestrogens acting as estrogen mimics may affect the production and/or the breakdown of estrogen by the body, as well as the levels of estrogen carried in the bloodstream.

Phytoestrogens - acting differently from estrogen - may affect communication pathways between cells, prevent the formation of blood vessels to tumors or alter processes involved in the processing of DNA for cell multiplication. Which of these effects occur is unknown. It is very possible that more than one of them may be working. Also, the effects in various parts of the body may be different.

Extraction and quantification of phyto-estrogens in foods

To investigate the biological effects of these compounds and to assess the exposure of larger cohorts or the general public, reliable data on the phytoestrogen content of food is necessary. Previously, food analysis for phytoestrogens was performed using either HPLC-UV or GC/MS. Now development of the first generic method for the analysis of phytoestrogens in food, using automated solid-phase extraction and liquid chromatography-tandem mass spectrometry has been a breakthrough. This method shows a good reproducibility and can be easily adapted to other phytoestrogens if required.

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