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Literature review on aspects of human consumption of soy

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Preface

The aim of the present paper is to provide a critical review of the existing knowledge and literature on the characteristics, potential beneficial and detrimental effects, and general knowledge of human consumption of soy products. Many aspects of the review will focus on human soy consumption in general; however special emphasis will be put on isolated soy proteins (ISP), and the textured ISP products of *Soy4 you* in particular.

Content of review:

1. Introduction to soy and human consumption of soy

Soy product are gradually gaining ground on the dinner tables, and can in the long run become healthy environmentally sustainble replacements for many meat products

The soybean (*Glycine max*) is a legume species native to East Asia, widely grown for its edible bean which has numerous uses. It is now grown commercially in many parts of the world, and soybeans are a globally important crop, providing oil and protein. Soybean is now the world's fourth most important crop, only surpassed by wheat, maize and rice. The bulk of the harvest is solvent-extracted, and the defatted soymeal (50% protein) makes the raising of farm animals possible on an industrial scale never before seen in human history. A relatively small proportion of the crop is consumed directly by humans.

In East Asia Soy has been consumed for centuries in many forms. In China, Japan, and Korea, soy products made are popular parts of the diet. The Chinese invented tofu and also made use of several varieties of soybean paste as seasonings. Japanese foods made from soya include miso, natto, kinako and edamame. Also many kinds of food are produced using tofu such as atsuage, aburaage, and so on. In Korean cuisine, soybean sprouts, called kongnamul, are also used in a variety of dishes, and are also the base ingredient in doenjang, cheonggukjang and ganjang. In Vietnam, soybeans are used to make soybean paste, tofu, soya sauce, soya milk.

The beans can be processed in a variety of ways. Common forms of soy include soy meal, soy flour, soy milk, tofu, textured soy protein (TSP), which is made into a wide variety of vegetarian foods, (some of them intended to imitate meat), tempeh, soy lecithin and soybean oil. Soybeans are also the primary ingredient involved in the production of soy sauce.

2. Content of soy

Soy beans have a relatively low content of gat and carbohydrates and a relatively high content of proteins, and furthermore contain a number of health promoting compounds

Together, soybean oil and protein content account for about 60% of dry soybeans by weight (protein at 40% and oil at 20%). The remainder consists of 35% carbohydrate and about 5% ash. Soybean consists of approximately 8% seed coat or hull, 90% cotyledons and 2% hypocotyl axis or germ.

Proteins Raw soybeans primarily contain legume proteins belonging to the globulin family of seed storage proteins called legumins and vicilins, or in the case of soybeans, glycinin and beta-conglycinin. Soy protein is generally regarded as stored protein held in discrete particles called "protein bodies" estimated to contain at least 60% to 70% of the total protein within the soybean. This protein is important to the growth of new soybean plants, and when the soybean germinates, the protein will be digested, and the released amino acids will be transported to locations of seedling growth. Legume proteins, such as soy, belong to the globulin family of seed storage proteins called legumin (11S globulin fraction) and vicilins (7S globulin), or in the case of soybeans, glycinin and beta-conglycinin. Soybeans also contain biologically active or metabolic proteins, such as enzymes, trypsin inhibitors, hemagglutinins, and cysteine proteases. The soy cotyledon storage proteins, important for human nutrition, can be extracted most efficiently by water, water plus dilute alkali (pH 7–9), or aqueous solutions of sodium chloride (0.5–2 M).

Carbohydrates Soybeans are relatively low in carbohydrates (35%), and nearly all the carbohydrates in soy are fibres and oligosaccharides. The principal soluble carbohydrates of raw soybeans are the disaccharide sucrose, the trisaccharide raffinose, and the tetrasaccharide stachyose. The oligosaccharides raffinose and stachyose are not digestible sugars in humans, and contribute to flatulence and abdominal discomfort, as undigested oligosaccharides are broken down in the intestine by native microbes, producing gases such as carbon dioxide, hydrogen, and methane. The insoluble carbohydrates in soybeans consist of the complex polysaccharides cellulose, hemicellulose, and pectin. The majority of the insoluble soybean carbohydrates can be classed as belonging to dietary fibres (Choi and Rhee, 2006).

Oils Raw soybeans contain app. 20% fat, and are thus relatively high in fat content. The major unsaturated fatty acids in soybean oil are the poly-unsaturated α-linolenic acid (Omega-3)(7-10%), and linoleic acid (Omega-6)(50-60%) and the mono-unsaturated oleic acid (20-25%). It also contains the saturated fatty acids, stearic acid (3-7%) and palmitic acid (5-10%) (Choi and Rhee, 2006).

Phytoestrogens Soybeans contain different isoflavones and coumestans, and further contain plant lignans, which are the principal precursor to mammalian lignans. However, the isoflavone content of soy is usually attracting the largest attention. Phytoestrogens are primarily interesting in relation to human intake because they have the ability to bind to human estrogen receptors, and thus influence bodily actions normally governed by natural estrogen levels. However, phytoestrogens have furthermore been reported to act as inhibitors of tyrosine kinases, influence signal transduction pathways, act against oxidation of DNA, and enhance the activity of anti-oxidant enzymes in various organs (Isanga and Zhang, 2008).

Isoflavones are a group of naturally occurring heterocyclic phenols, which are present in soy bean at levels of 0.1 to 5 mg/g (Isanga and Zhang, 2008). The three major groups of isoflavones found in soybeans are genistein, daidzein, and glycitein, and the genistein and daidzein forms constitute the absolutely largest proportion of isoflavones in soy. Isoflavones can generally exist in soybeans as aglycones (daidzein, genistein, and glycitein), glycosides (daidzin, genistin, and glycitin), acetylglycosides (acetyldaidzin, acetylgenistin, and -acetylglycitin), and malonylglycosides (malonyldaidzin, malonylgenistin, and malonylglycitin). Isoflavones in the acetylglycoside and malonylglycoside form are not bioavailable for the human body, whereas the glycoside forms can be deglycosinated into the aglycone forms, which are absorbable in the human intestine (Isanga and Zhang, 2008). The deglycosination of the glycoside forms into the aglycone forms was previously thought to be mediated by colon microflora, but experiments have shown that it is mediated by enzymes in the intestinal cells (Nielsen and Williamson, 2007). The enzymatic conversion of the glycoside form is very dependent on - the vitality of the intestine cells, - whether other food items compete for the enzymatic activity, - blood circulatory parameters, - etc. Another transformation of daidzein into the isoflaonoid equol is mediated by a specific microflora, however only an approximated 40% of the human population has this specific microflora in the intestine. Interestingly, a larger proportion of people from East Asia have this microflora than people of Western origin. All in all, the bioavailability of ingested isoflavones is thus depending on: - the ingested soy product, - which food the soy has been ingested along with, - the intestinal microflora, - and several other factors. This makes it very difficult to predict and standardize the absorption rate of biologically active isoflavones in e.g. human experiments, and to issue standardized recommendations for intake of isoflavones.

Minerals The mineral content of soybeans, determined as ash, is about five percent. When soybeans are processed, most of the mineral constituents go with the meal and few with the oil. The major mineral constituents are potassium, calcium and magnesium. The minor constituents comprise trace elements of nutritional importance, such as iron, zinc, copper etc. The biological availability of minerals may be impaired somewhat as a result of the presence of phytates in soybeans and soybean products.

Antinutritional elements Soybeans contain a number of elements which have unwanted or detrimental effects in the human organism. - *Phytic acid* or the salt form *phytate* acts as an antioxidant, and furthermore has a strong binding affinity to important minerals, such as calcium, iron, and zinc, although the binding of calcium with phytic acid is pH-dependent and ascorbic acid (vitamin C) can reduce phytic acid's effect on iron. When iron and zinc bind to phytic acid they form insoluble precipitates and are far less absorbable in the intestines. This process can therefore contribute to iron and zinc deficiencies in people who rely their mineral intake on food containing high amounts of phytic acid for. Simple cooking will reduce the phytic acid to some degree. More effective methods are soaking in an acid medium, lactic acid fermentation, and sprouting (Isanga and Zhang, 2008). - *Trypsin inhibitors* are molecules, which bind to the enzyme trypsin, and thereby inhibit the degradation of certain lipid bonds among amino acids (lysine and arginine) of proteins in the intestine of humans and animals. This prevents the uptake of amino acids, and further detrimentally affects the enzyme balance and may cause hypertrophic pancreas responses. Soy beans contain at least two types of trypsin inhibitors, and the biological function of the inhibitors is thought to be, that animals will avoid eating the raw beans in the long run (Selgrade et al., 2009). Heating, fermentation and leaching eliminates the activity of the inhibitors (Isanga and Zhang, 2008). - *Lectins* are a natural part of many legumes, and are toxic to humans at higher levels. In mature raw soybeans the lectin levels are low, whereas in green immature beans the levels may be higher. Lectins bind to the gut wall and reduce epithelial cell vitality and functionality, and thus inhibit the absorption of vital nutritional elements into the body. Possible beneficial effects of lectins, e.g. their anti-cancer effects, have, however, been debated in science (Isanga and Zhang, 2008). Leaching, cooking and (moist) heat treatment deactivates the lectins (Isanga and Zhang, 2008). - *Soluble carbohydrates* are broken down during fermentation, soy concentrate, soy protein isolates, tofu, soy sauce, and sprouted soybeans are without flatus activity. On the other hand, there may be some beneficial effects to ingesting oligosaccharides such as raffinose and stachyose, namely, encouraging indigenous bifidobacteria in the colon against putrefactive bacteria

3. Methods of assessment of the nutritional value of proteins

Proteins are nitrogen-containing substances that are built by amino acids. They serve as the major structural component of muscles and other tissues in the body. In addition, they are used to produce hormones, enzymes, haemoglobin, and several other vital components. Proteins can also be used as energy; however, they are not the primary choice as an energy source. For proteins to be used by the body they need to be metabolized into their simplest form, amino acids. Twenty amino acids have been identified as needed for human growth and metabolism. Twelve of these amino acids (eleven in children) are termed nonessential, meaning that they can be synthesized by our body and do not need to be consumed in the diet. The remaining amino acids cannot be synthesized in the body and are described as essential, meaning that they need to be consumed in our diets. The absence of any of these amino acids will compromise the ability of tissue to grow, be repaired or be maintained (Hoffman and Salvo, 2004).

It is important to understand that proteins are complex molecules, and that different proteins sources and different forms of the same protein can possess differences in: - which amino acid they contain, - their water solubility, - their stability in acidic and alkaline solutions, and - how easily they are degraded and absorbed in the human body. Proteins are found in many plant products, but not all plant proteins contain all the essential amino acids (or not in adequate amounts) for the human body to sustain a natural metabolism. A protein source is called a “Complete protein” if it delivers all the protein related components a human body needs.

To standardize the comparison of protein sources, numerous methods exist to determine protein quality, such as – “protein efficiency ratio”, “biological value”, “net protein utilization”, and “protein digestibility corrected amino acid score”. - The *protein efficiency ratio* (PER) determines the effectiveness of a protein through the measurement of animal growth. This technique requires feeding rats a test protein and then measuring the weight gain in grams per gram of protein consumed. The computed value is then compared to a standard value of 2.7, which is the standard value of casein protein. Any value that exceeds 2.7 is considered to be an excellent protein source. However, this calculation provides a measure of growth in rats and does not provide a strong correlation to the growth needs of humans. - *Biological value* (BV) measures protein quality by calculating the nitrogen used for tissue formation divided by the nitrogen absorbed from food. This product is multiplied by 100 and expressed as a percentage of nitrogen utilized. The BV provides a measurement of how efficient the body utilizes protein consumed in the diet. A food with a high value correlates to a high supply of the essential amino acids. Animal sources typically possess a higher biological value than vegetable sources due to the vegetable source’s lack of one or more of the essential amino acids. There are, however, some inherent problems with this rating system. The BV does not take into consideration several key factors that influence the digestion of protein and interaction with other foods before absorption. The BV also measures a protein’s maximal potential quality and not its estimate at requirement levels. - *Net Protein Utilization* (NPU) is similar to the BV except that it involves a direct measure of retention of absorbed nitrogen. NPU and BV both measure the same parameter of nitrogen retention, however, the difference lies in that the BV is calculated from nitrogen absorbed whereas NPU is from nitrogen ingested (Hoffman and Falvo, 2004).

- *PDCAAS* The most widely accepted method is *Protein Digestibility Corrected Amino Acid Score* (PDCAAS). In the PDCAAS analyses the targeted protein source is analysed and compared to a reference protein source to assess whether the amino acid profile meets the demand of essential amino acids and nitrogen in a hypothetical 2-5 years old child, which is believed to be the age group where the demand for the "Complete protein" is largest. Hereafter a correction is made for the actual digestibility of the protein, by feeding the protein to rats and analysing how much of the protein is recovered in the faeces, and finally the result is truncated to 100% .The PDCAAS results in a score from 0 to 1.00, where 1.00 indicates that the protein provides the "Complete Protein", whereas e.g. the score 0.70 indicates that the source does not live up to the criteria of providing the adequate amounts of the protein related elements which a human body needs.

The method is recognised by many to currently be the best method, however critics emphasises that the method has certain flaws and sources of error (Schaafsma, 2000). Primarily the method is criticized for uncertainties about the actual amino acid and nitrogen needs of a 2-5 year old child, and whether the needs of this age group is representative for all age groups and phenotypes of humans (Sarwar, 1997). Moreover it is criticized that the method does not encompass the fact that the micro flora of the last part of the intestine metabolises a part of the amino acids and proteins, and that it therefore probably would be more correct to measure the amounts of amino acids and proteins at the transition between the small intestine and the colon (Schaafsma, 2000). Furthermore the analyses of rat faeces is not necessarily representative for humans, as the intestinal micro flora and the metabolic needs of rats are different than human, and that rats for example have a higher need for sulphur rich amino acids to maintain their fur production than humans (Schaafsma, 2000). Supporters of the method, however, claims that the method gives sufficiently covering results to declare the nutritional and efficiency of use of protein sources within a feasible economic frame for the analyses (WHO). Minor differences are however found between the results of individual laboratories, even though the same soy material is tested (Hughes et al., 2011).

The American Food And Drug Administration (FDA) and UN's food and health organizations (FAO/WHO) recognizes the PDCAAS method to be the best current method to assess to which degree a protein source delivers the "Complete protein" (Hughes et al., 2011). In the European Union, EFSA expresses reservations about the method (EFSA, 2013), but does however not offer any alternative methodologies.

PDI The Protein Dispersibility Index (PDI) is a method of comparing the solubility of a protein in water, and is widely used in the soybean product industry to evaluate the protein quality before and after a specific industrial process. A sample of a specific refined soy product is ground, mixed with a specific quantity of water, and blended together at a specific rpm for a specific time. The resulting mixture and original bean flour then have their protein content measured using a combustion test (see below), and the PDI is calculated as the percentage of the protein in the mix divided by the percentage in the flour. A PDI of 100 therefore indicates total solubility (Batal et al., 2000). It has been shown that the PDI can be affected, not only by the type of soybean used, but also by manufacturing processes (Batal et al., 2000).

The Combustion Method The combustion method involves burning a sample in an oxygen-rich atmosphere at high temperatures and analysing the resulting gases. This process has three stages. Combustion: Once the sample is weighed and purged of any atmospheric gases, it is heated in a high-temperature furnace and rapidly combusted in the presence of pure oxygen at about 1000ºC. Reduction and adsorption: The combustion products, mainly carbon dioxide, water, nitrogen dioxide, and nitrogen gas, are collected and allowed to equilibrate. An aliquot of the gas mixture is passed over hot copper to remove any oxygen and catalytically convert nitrogen dioxide to nitrogen. The sample is then passed through a trap that removes carbon dioxide and water. Quantification: The total nitrogen is measured by thermal conductivity (Marco et al., 2002).

4. Nutritional values of soy proteins

Soy protein isolate is a "Complete Protein", and thus contains all the protein related components to sustain normal growth in a 2-5 year old child.

Soy protein isolate is one of the few plant sources of protein, which is claimed to be a "Complete Protein" (PDCAAS = 1.00) (Hughes et al., 2011; Hoffman and Falvo, 2004), and is thereby in line with egg white, and the milk proteins whey and casein (all with PDCAAS = 1), whereas e.g. raw soy beans and beef only have the score 0.92, black beans score 0.75, other legumes score 0.70, peanuts score 0.52, and wheat proteins are as low as 0.25 (Hoffman and Falvo, 2004).

However, different cultivars of soy bean have different compositions of amino acids and proteins, and thus the resulting nutritional values vary accordingly, and scores between 0.92 and 1.00 have been published on isolated soy proteins. (Hughes et al., 2011). Particularly the amounts of the sulphur rich amino acids methionine and cysteine may be too low in some cultivars, and thus reduce the PDCAAS score. The processing of the soy protein isolate may also influence several factors related to the PDCAAS values. Primarily, the temperature- and pressure treatments during the processes are critical, as e.g. the amino acid lysine is sensitive to high temperatures, and may be lost, resulting in lower PDCAAS values (Batal et al., 2000).

To be on the safe side, the American Soy Export council does not promise a higher PDCAAS value than 0.90 in soy protein isolates, although the values are usually closer to, or equal to 1.00. Generally soy protein isolate can be expected to deliver all the amino acids and nitrogen, which the body needs, however it is always recommended to let ISP be part of a varied protein intake from several sources. The PDCAAS value of *Soy4 you*® has been analysed to be 1.00.

5. Effects on anti-nutritional elements of the processing of soy beans

Soy product contain quite different amounts of health promoting and detrimental elements depending on the pre-processing of the products

Raw soy beans contain a number of elements, which are unwanted, either because they cause anti-nutritional digestion- and absorption-effects, or because they are irritating or poisonous to the body. The unwanted elements include: - *Lectins*, which react with the carbohydrate component of cell membranes, potentially causing cell-injuries and -deaths, and adversely affect the gastrointestinal, immune, and other systems of humans; *Protease inhibitors*, which interfere with the digestion of proteins in the intestine; - *Phytates*, which tie up minerals like calcium, zinc, and iron. Thus, all soy products used for human consumption have to go through some degree of processing before they become healthy to consume.

Maceration and boiling The simplest traditional form of processing the raw or dried beans is maceration and boiling. If the process is performed balanced and adequately, it reduces the toxicity of the lectins, breaks down the protease inhibitors, and partially reduces the activity of the phytates (Karkle and Beleia, 2010). Most of the oils, isoflavones, sugars and proteins are not reduced by maceration and cooking.

Soy milk It is produced by soaking dry soybeans and grinding them with water, pressing the fluid out, and subsequently boiling and sieving the “milk” out. Most antinutritional elements are unchanged, compared to raw soybeans.

Fermentation Another traditional way of processing the soy beans is fermentation. The fermentation can be performed by many different microorganisms, but the most used are *Saccharomyces, Aspergillus* and *Lactobacillus*, degrading sugars into alcohol and lactic acid, respectively. The processes have different effects on the composition, depending on the duration and other factors, but generally the end product contains low amounts of lectins, phytates, and protease inhibitors. Many of the isoflavones, sugars and proteins are reduced or changed by fermentation.

Soy meal Soy meal is the material remaining after solvent extraction of oil from soybean flakes, with 50% soy protein content. The meal is 'toasted' (heat treatment with moist steam) and ground in a hammer mill (Lin et al., 2000).

Soy flour Soy flour is made from soybeans ground finely enough to pass through a fine mesh where special care is taken during desolventizing to minimize denaturation of the protein to retain a high protein dispersibility index (PDI), for uses such as food extrusion of textured soy protein. It is the starting material for production of textured soy protein (TSP), soy proteins isolate (SPI), and soy proteins concentrate (SPC) (Lin et al., 2000).

Isolated Soy Protein Edible ISP is derived from defatted (alcohol extracted or cold pressed) soy flour with a high Protein Dispersibility Index (PDI). The aqueous extraction is carried out at a pH below 9. The extract is clarified to remove the insoluble material and the "supernatant" is acidified to a pH range of 4-5. The precipitated protein-curd is collected and separated from the whey by centrifuge. The curd is usually neutralized with alkali to form the sodium proteinate salt before drying. The ISP can be further refined by extruding the product into Textured Soy Protein Isolate (TSP).

Soy protein concentrate SPC is produced by immobilizing the soy globulin proteins while allowing the soluble carbohydrates, soy whey proteins, and salts to be leached from the defatted flour. The protein is retained by one or more of several treatments: leaching with 20-80% aqueous alcohol/solvent, leaching with aqueous acids in the isoelectric zone of minimum protein solubility, pH 4-5; leaching with chilled water (which may involve calcium or magnesium cations), and leaching with hot water of heat-treated defatted soy meal/flour. The SPC can be further refined by extruding the product into Textured Soy Protein Isolate (TSP).

Textured Soy Protein TSP is extruded from defatted (alcohol extracted or cold pressed) soy flour, or the refined products ISP or SPC. The flour/proteins can be extruded into various sizes and shapes (chunks, flakes, nuggets, grains, and strips), exiting the nozzle while still hot and expanding as it does so. During the process, the defatted thermoplastic proteins are heated to 150-200°C, which denatures them into a fibrous, insoluble, porous network that can soak up as much as three times its weight in liquids (Hill et al., 2006). Extrusion temperatures are typically 120-140°C (Lin et al., 2000). The process may further involve the addition of colouring and flavours (Deliza et al., 2002). Several factors in the process, including cooking temperature, moisture, pressure, product temperature at extrusion, and colouring agents are critical for the hardness, gumminess and chewiness of the product (Lin et al., 2000). The 7S and 11S subunits of soy proteins are major components for the texturization, and both start to unfold when heated above 100 °C and become totally unfolded at 140 °C (Lin et al., 2000). Soybean meal must be heat-treated in order to reduce or eliminate anti-nutritional factors, such as trypsin inhibitors and phytates, and here the heating and extrusion processes are critical. Under-heating results in high levels of anti-nutritional factors, such as trypsin inhibitors remaining in the processed soybean meal (Thomas et al., 1997). Over-heating can result in a significant reduction in the digestible amino acid content of the soybean meal by Maillard reactions, in which reactive sugars are bound to amino acids, particularly lysine (Jeunink and Cheftel, 1979). The resulting PDCAAS values are thus easily affected by any improper moisture, pressure, temperature and mechanical shear in the process (Singh et at., 2007), and it is very important to identify and aim at soybean meal that has been processed just right (the "Goldilocks" value). The extrusion process has a tendency to increase the amount of soluble fibres and to decrease the insoluble fibre content (Singh et at., 2007). Minerals are not directly affected by the processes; however changes in fibre composition, and decreasing effects on mineral binding components, such as pythates and tannins, have positive effect on the resulting human absorption of minerals (Singh et at., 2007). Phenolic compounds, such as the isoflavonic health related bioactive aglycone compounds genestein and daidzin are prone to decrease under too high temperatures, however the majority are transformed to the glycoside analogues, which are readily reversed to the aglycone form by the micro flora in the human intestine, whereas a proportion may be transformed into the non-bioactive acetyl- and malonyl- forms. (Singh et al., 2007).

Properly manufactured Textured Soy Protein, such as Soy4you® and Soy4you øko® contains no trypsin inhibitors, contains drastically lowered pythates, tannins, and lectins, and contains proteins which are easier to digest for the human organism.

6. Health aspects of soy and ISP consumption

A moderate and balanced intake of soy products can affect the health in a positive way, whereas an excessive and unbalanced intake can have unwanted effects in humans with already developed diseases, genetic predispositions and unbalances in the body.

6.1. General comments

Reading popular information about the health aspects of soy, the impression is rather ambiguous, as some popular publications and homepages highly praise the health aspects soy, whereas others, in strong terms, warn against the intake of soy. The reason for the vehemence in the arguments probably has to be found in the fact that, particularly in the USA, soy has been shouted out as a "Miracle food". In a misunderstood desire to be extra healthy, this has, in an unbalanced manner, led some people to base a very large part of their diet on soy based foods, or in other ways to exaggerate the intake of soy derived components, e.g. isoflavones. As the "American style" of argumentation is often rather overdramatized, the vehemence in the arguments should probably mainly be perceived as well meant warnings against an exaggerated intake of soy, whereas many of the exaggerated praising popular references should be taken as arguments for improved sale, and similarly taken with a grain of salt.

Reviewing the scientific literature, the picture is less dramatically ambiguous; however it is clear that when setting up experiments and hypotheses, some science groups have clearly had the goal to prove health benefits, whereas other have clearly had the goal to prove detrimental effects of soy. However the scientific integrity is intact in the majority of the present soy related science, and particularly some of the meta-analyses and collective reviews of many individual experiments provide reliable information on the health aspects of soy intake.

Scientific investigations of the health aspects of soy intake can roughly be divided in three sections: - *Human cohort studies*, where large groups of persons are followed for a time period, and are asked to report e.g. their specific food intake, income and social status, exercise level, and health history, - *Human intervention experiments*, where groups of specifically selected persons are asked to perform (eat/exercise/etc.) in a specific manner for a specific time period, - *Laboratory animal experiments*, where uniform groups of laboratory animals (often rats or mice) are used as human model organisms, and subjected to different conditions and diets.

All three ways of performing experiments and analyses may provide valuable information to the knowledge of the health effects of soy intake of average people. However all three ways both have advantages and disadvantages; *Human cohort studies* have the advantage that they can be performed on very large groups of people, providing good basis for statistical conclusions, and elements of the individual persons entire life history can be part of the analyses – the disadvantages include that e.g. the reports of self-chosen random food intakes may give a very "noisy" set of subcategories, making it difficult to pinpoint specific health effects to specific food subjects; *Human intervention experiments* have the advantage that they can performed in such a way that specific amounts of a food source can be pinpointed to specific health effects, although human study objects seldom can be forced to eat completely uniform diets and perform all other aspects of life in a uniform manner – the disadvantages include that the studied groups often are relatively small and heterogeneous leaving room for less firm statistical conclusions, that the time span of the experiment often is relatively short, and that humans cannot be subjected to deliberate overdoses of substances – *Laboratory animal experiments* have the advantage that animals can be specifically designed/bred to be very uniform and to have predispositions for specific diseases and anomalies e.g. cancer, gout, obesity, etc. Furthermore animal experiments are not subject to as strict ethical restrictions as human experiments. This allows the researchers to design experiments in which the toxicological effects of specific elements are tested on specific diseases or disorders. The results can easily be reproduced and offers a high degree of statistical validity, and the applied doses can be set so high that specific responses can be provoked out. The disadvantages of using laboratory animals includes that no animals are sufficiently similar to humans to exactly simulate human responses to particular elements or compounds. Furthermore the lives of humans are much more complex than the lives of laboratory animals in terms of external influences and complex diets, and thus important complex interactions and cross-reactions may be missed and disregarded.

Human cohort experiment are the best to illustrate the response of average consumers, human intervention experiments are good at estimating the responses on a more specific level, and animal experiments are good at provoking both beneficial and detrimental effects, which sometimes are comparable to human effects.

6.2. Effect of soy on the composition of cholesterol in humans

Intake of soy products has a documented positive effect on the composition of cholesterol types in the human body.

It is a well-documented fact that the risk of e.g. cardio-vascular diseases is closely linked to the composition and amount of cholesterol in the body (EFSA, 2011). Cholesterols are lipids, and act as a precursor for the biosynthesis of steroid hormones, bile acids, and vitamin D, and are an important part of cell membranes in all parts of the body. Cholesterol is insoluble in the blood, but is readily transported in the blood when conjugated to different types of lipoproteins. In connection to health issues, the cholesterols are roughly divided into the “good” cholesterol, HDL (High Density Lipoprotein) and “bad” cholesterol, LDL (Low Density Lipoproteins). High levels of LDL are significantly associated with cardio-vascular diseases. Cholesterol is both synthesized in the body and is supplied with ingested foods.

A long line of investigations (e.g. Hermansen et al., 2003 and 2005; EFSA, 2011) have shown that intake of soy lowers the amount of LDL, whereas the concentration of HDL remains unchanged. The mechanisms of action remain uncertain and are probably linked to several components of the soy beans. However, it seems certain that soy proteins and their abilities to bind to cholesterol, and the resulting molecules cause the primary effects. Parallel to this, isoflavones and sterols have positive effects on the metabolism of fatty acids cholesterols in the body, and fibre content have metabolism stimulating effects.

The American Food and Drug Administration (FDA) in 1999 performed (and verified in 2013) a thorough revision of the existing knowledge and experiments on cholesterols and soy proteins (FDA, 2013). FDA concluded that it is scientifically demonstrated that intake of soy proteins together with a diet of few saturated fatty acids has a lowering effect on LDL cholesterol , and stated that a daily intake of minimum 25g of soy protein significantly reduces the risk of cardio-vascular diseases (FDA, 2013). A similar statement has been issued by the British Health authorities (JHCI) in 2002. Following a so called "Health Claim Application" a long list of EU's most prominent researchers were asked to evaluate whether it, from the existing evidence, is possible to claim that soy intake has a lowering effect on LDL cholesterol, a thereby has a Health promoting effect. In a very strict scientific compilation of the very heterogeneous existing scientific evidence, it was assessed that evidence definitely pointed in the direction of a positive effect, but that the evidence was too heterogeneous and incomparable to conclude that there exists an unambiguous connection between a reduced risk of cardio-vascular diseases and intake of soy proteins (EFSA, 2011). However, in any case, completely or partially reducing the intake of animal derived proteins and replacing these with soy proteins will have positive effects on the cholesterol composition of the body to, as many animal derived proteins have decidedly increasing effects on the levels of LDL cholesterol.

Particularly fat reduced soy products, such as Soy4you® and Soy4you øko® have a positive effect on the cholesterol composition of the human body.

6.3. Effect of soy on breast cancer

Human experiments show marginally positive effects in preventing and treating breast cancer with soy.

Oestrogen is believed to play a central role in breast cancer development and progression. Blocking the effect of oestrogen, either by inhibiting oestrogen action or by reducing oestrogen production, has been widely used in breast cancer treatment, and soy isoflavones have shown to exert such effects (Shu et al., 2009). Isoflavones from soy have further been shown to have other anticancer effects, including the inhibition of DNA topoisomerase I and II, proteases, tyrosine kinases, inositol phosphate, and angiogenesis and may also boost immune responses (Shu et al., 2009). Consumption of soy food has, however, also been related to increasing the risk of breast cancer in some epidemiological studies (Trock et al., 2006), as genistein has been shown to enhance the proliferation of breast cancer cells *in vitro* and to promote oestrogen-dependent mammary tumour growth in ovariectomized rats (Trock et al., 2006). In addition, breast cancer treatments may lead to a decrease in the endogenous estrogen supply of survivors, and a concern has been raised as to whether soy isoflavones may exert their estrogenic effects, promote cancer recurrence, and, thus, negatively influence overall survival.

In a large study, approximately 200.000 people of many ethnic lineages (Multi-ethnic Cohort Study) were followed for many years, and their diets and history of diseases were meticulously registered and analysed for a multitude of correlations (Conroy et al., 2013). Of these, 3841 persons were selected, because they were more than 50 years old and were diagnosed with breast cancer during the registration period. The conclusion of the analyses, including all ethnic groups, was that the amount of soy neither had a significant effect on the breast cancer related death frequency nor the duration of the courses of disease. However, within individual ethnic groups, significant positive effects on the duration of the courses of disease were registered (Conroy et al., 2013). This is in line with 5 smaller studies on American and Chinese Population groups (Boyapati et al., 2005; Fink et al., 2007; Guha et al., 2009; Shu et al., 2009; Caan et al., 2011), which all showed significantly slower development of breast cancer. In conclusion, statistically, it has not been established that intake of soy has a direct influence on the diagnosing of breast cancer, but that intake of soy very likely has a positive influence on the course of the disease.

A large proportion of the isoflavones have been removed from Soy4you®, while a larger proportion remains in Soy4you øko®.

6.4 Effect of soy on prostate cancer

Human experiments show marginally positive effects in preventing and treating prostate cancer with soy.

The components of soy primarily thought to suppress cancer are the soy isoflavones daidzein, genistein, and glycitein. Isoflavones accumulate in the prostate gland and have been shown to modulate endogenous hormones relevant to prostate carcinogenesis (Gardner et al., 2009). Soy isoflavones also exert nonhormonal effects to suppress cancer by altering expression of genes associated with cancer progression, and through pathways that target cell cycle and apoptosis in androgen prostate cancer cells (Handayani et al., 2006; Hamilton-Reeves et al., 2008 and 2013). However, a compilation of multiple human cohort studies, including groups of many ethnic origins and many types and frequencies of soy intake, showed that significant positive effects are relatively rare, and that most studies only show marginally positive effects (Ahmad et al., 2013; Perabo et al, 2008)).

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6.5. Effect of soy on women's menopause

Positive effects of soy intake on discomforts associated with the menopause of women are among the best documented in the catalogue of soy effects on human health

In connection to the menopause the ovaries stops producing oestrogen, and this affects the tissue of the body and bodily functions in several ways. Many women experience hot flashes, heart palpitations, dry vaginal mucous membranes, and eventually an increased rate of bone fractures. Isoflavones from soybeans and other oestrogen-like phytoestrogens from e.g. soy and red clover have for many generations been used by women against discomforts caused by the menopause, and modern scientific investigations have demonstrated that the effects are scientifically significant.

Osteoporosis Human bones are not just dead calcareous elements providing structure to the body, but contain living cells which continuously build and degrade bone tissues, e.g. making the healing of bone fractures possible. The balance between the activity of the bone-degrading and -building cells is controlled by many different factors including the concentration of oestrogen in the blood. Therefore this balance can be affected by the consumption of phytoestrogen from soy, primarily inhibiting the activity of the bone degrading cells.

A large number of scientific investigations (EFSA, 2012), both on large and small population groups, show result which are ranging from significant to no effects of intake of isoflavones on the bone status and associated biological markers during and after the onset of menopause. Within many of the experiments, the results are relatively heterogeneous, which probably largely can be ascribed to the fact that many other factors, such as smoking and exercise, has a strong influence on the status of human bones. Investigations have demonstrated a dose-response dependent effect, and demonstrate that isoflavones only has an effect on the bone degradation if the persons also consume sufficient amounts of calcium in the diet (Kuhnle et al., 2011). As some soy products have a temporary tendency to decrease the absorption of calcium and other minerals, this emphasises the importance of consuming soy as part of a varied diet.

The effect of soy on other menopause related discomforts, such as hot flashes, heart palpitations and dry vaginal mucous membranes have similarly been demonstrated in a large number of scientific investigations (EFSA, 2012). The discomfort symptoms can be relatively difficult to quantify, as they are based on subjective evaluations of the involved, and there is no scientific consensus of the mechanisms of action of the isoflavones on the symptoms (Andrikoula et al., 2009). The results are ranging between clearly perceptible to no effects. A positive result is presented by Bolaños-Diaz et al., (2011), who in a comparison between medical hormone treatments and treatments with isoflavones, demonstrate that both groups had positive effect on life quality parameters, as compared to women receiving no treatments. Combining the medical and isoflavones treatments had no additional effect (Bolaños-Diaz et al., 2011). Other researchers (Reed et al., 2013; Amato et al., 2012; Burke et al., 2003) claim that effects of soy on the life quality of women in menopause is mainly due to placebo effects and differences in ethnic origin and the thereby accompanying differences in their diets during life.

In a so called ”Health claim application”, a selection of scientists from EU were asked to evaluate if it from the existing scientific knowledge can be claimed that isoflavones unambiguously affects the bone status and relieves symptoms of the menopause. Their conclusion was that a substantial amount of evidence points in the right direction, but that the evidences remain too in-comparable and fragmented, and that no unambiguous cause-effect has been established between isoflavones and the bone status and other menopause related discomforts. The American Drug and Food Administration (FDA) on the other hand, have established a connection between intake of soy and discomforts of menopause, and recommend a frequent intake of soy to relieve discomforts (Welty et al., 2007).

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6.6. Soy and human reproduction

No scientific investigations have shown detrimental effects of a moderate intake of soy on niether men's or women's fertility. A moderate soy intake of soy has not been shown to affect children in the foetal or infant stages, however pregnant women should not exaggerate the intake of soy.

Even though isoflavones and other phytoestrogens in many ways resemble the humanly produced oestrogen, they have different modes of action in the human body. For example genestein has a 30 times poorer binding ability to one of oestrogens binding sites, ERβ, as compared to the other, ERα (Cederroth et al., 2012). ERβ is the primary binding site in the male prostate gland, which produces the majority of the seminal fluid and controls a large part of the male reproductive abilities, and it thus to be expected that the isoflavones have a relatively smaller effect on male reproduction as compared to female (Matthews et al., 2003). The number of scientific investigations evaluating the effect of phytoestrogens on the reproduction of men is limited, but no results points in the direction of neither a promoting nor a detrimental effect on the reproduction of men (Cederroth et al., 2012). A number of investigations on rats and mice indicate that a life-long excessive intake has a negative effect on the sexual development and fertility in males (Cederroth et al., 2012).

In women, the effect of the intake of isoflavones on the reproductive ability is more weel documented (Cederroth et al., 2012), and in a compilation of all the known investigations (Hooper et al., 2009) the connection between soy intake and different sexually related hormones and factors in fertile women was evaluated. The results showed that intake of isoflavones does not directly influence the natural oestrogen levels in the human body, but can have weak effects on some of the hormones which are associated with the menstrual cycle, and that intake of soy can be coupled to weakly prolonged menstrual periods. The results showed neither an increased nor a decreased ability to become pregnant or higher frequency of miscarriages or abnormal birth events.

Toxicological animal experiments on mice and rats have shown that exposure to large amounts of phytoestrogens can provoke different physiological changes in the reproductive organs (e.g. Gallo et al., 1999; Lamartiniere et al., 1998; You et al., 2002). Among farmers a well-known concept is "clover disease", where pregnant grassing animals almost exclusively feeding on highly phytoestrogen rich clover will have an increased frequency of problems with pregnancies, and that the male offspring often will have a poorer fertility. So pregnant women should probably not base their diet exclusively on isoflavone-rich products, but let soy be part of a varied diet.

The foetal and infant stages are critical for the development of multiple physical traits in a human being. Particularly the sexual development is delicate, and concerns have been raised about the inclusion of phytoestrogens in the diet of pregnant women, breast feeding women and infants. A critical review of the existing publications reveals no reason for concern, as the results do not show any increased frequencies of abnormalities at moderate intakes of soy. An investigation of relatively high intakes of soy by a vegetarian group of women showed a slightly elevated frequency of abnormalities in new-born boys, however, the cases were also linked to cases of fly in the early pregnancy and to deficit iron levels in the diet of the inflicted women (North et al., 2000). Isoflavones are only very sparsely transmitted to the breast milk (Badger et al., 2009), so breast feeding women can safely include soy as part of a varied diet.

Soy product have a number of nutritional qualities, which makes them valuable as ingredients in infant formulas, and soy has for more than 40 years routinely been used for infants in large part of the Western world (Badger et al., 2009). In girls, a large number of studies of the effect of soy in infant formulas collectively show very few or no side effects or changes in e.g. the onset of puberty or other reproductive characteristics, however some studies showed a weakly increased risk of longer menstrual periods and menstrual pains (Strom et al., 2001), and for uterine fibroids in adult women who consumed soy as infants (D'Alosio et al., 2010). In boys, research show no or very moderate side effects in e.g. the onset of puberty and other reproductive traits (Cederroth et al., 2012). A long line of animal experiments collectively show very few tendencies of changed patterns of sexual development and life course as a consequence of soy intake (Cederroth et al., 2012).

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6.7. Soy and mineral uptake

Scientific investigations show that balancing the intake of soy with other food sources eliminates the risk of mineral deficits.

Soybeans and long line of other plant based food items contains phytates and oxylates, which are indigestible in the human organism, and reduces the uptake of important minerals such as calcium, iron, magnesium and zinc by producing insoluble chelates. Heat treatment of soy products, such as the products of Soy4you will dramatically reduce the content of phytates and oxylates. Investigations have shown that any reductions in mineral uptake during soy intake is of a very temporary nature, and that consumption of other mineral rich food items quickly will compensate for the deficits (Jovaní et al., 2001). It is thus important to give the body frequent breaks in the soy intake so a healthy mineral balance can be maintained.

The heat treatment of Soy4you® and Soy4you øko® dramatically reduces the content of phytates and oxylates, which potentially disturbs mineral uptake in the human intestine.

6.8. Soy and allergies

The products of Soy4you are heat treated at relatively high temperatures, which causes a deactivation of a large proportion of the allergy causing proteins

In Denmark, soy allergy is not particularly widespread (less than 0.7% in adults and 1.4% in small children (Sicherer, 2011)), and in small children, the prognosis of outgrowing the allergy is quite good. However food allergies are a serious problem, and people should be aware of their bodily responses to ingested food items. Soy beans is a legume, and some people experiencing allergic symptoms towards soy proteins will also experience allergic symptoms towards other legumes, e.g. green peas, lentils or peanuts. The reason for this is that the proteins in the legume food items are molecularly similar, and that the body cannot distinguish between the different allergy causing compounds. It is called a cross-reaction, however not all people allergic to soy will experience this. The only certain way to establish the allergy causing agents is a provoked test by a medical doctor.

Raw soy beans contain approximately 33 proteins, which potentially are allergenic (Amnuaycheewa, 2010). The proteins cause potential allergic reactions because they resemble the human body's own immunoglobulin E antibodies, which bind to receptors on mast cells and cause the allergic reaction. Heat and pressure treatment alters the shape of many proteins and dramatically reduce the allergenic potential of the proteins.

Heat and pressure treated soy products, such as Soy4you® and Soy4you øko reduces the risk of evolving allergic reactions towards soy proteins

6.9. Metabolism related issues of soy intake

Isoflavones may have negative on the metabolism of people with disorders in the thyroid balance. Soy4you® and Soy4you øko contain low levels of isoflavones

Soybeans also contain moderate amounts of purine, which also is present in almost all food items. Consuming large amounts of purines can make gout worse, and persons with gout should not eat a lot of purine rich products. Moderate intake of purine-rich vegetables or protein is not associated with an increased risk of gout (Hyon et al., 2004)

Goitrogens are substances that suppress the function of the thyroid gland by interfering with iodine uptake, which can, as a result, cause an enlargement of the thyroid, i.e., a goiter. In *in vitro* studies and in rats, isoflavones have been shown to compete for an enzyme that is used to make thyroid hormone and partially inactivate thyroid peroxidase, an enzyme required for the synthesis of thyroid hormones. However, not only is the rat extremely sensitive to goitrogenic problems in comparison to humans, but despite inhibiting enzyme activity, soy-containing diets allow normal thyroid function. Soy may somewhat inhibit the absorption of synthetic thyroid hormone, such as synthroid, which is taken by hypothyroid patients. However, foods in general have this effect, as do fibre-rich foods, herbs and many drugs. For this reason, thyroid hormone is taken on an empty stomach and hypothyroid patients can still consume soy products. If there is any small effect on absorption, the medication dose can easily be adjusted accordingly. There are however, two relevant clinical situations related to soy and thyroid function yet to be evaluated. One involves individuals with subclinical hypothyroidism, which represents about five per cent of the general adult population but a higher percentage among individuals over the age of 60. Patients with this condition have normal levels of the two primary thyroid hormones, thyroxine and triiodothyronine, but elevated levels of thyroid stimulating hormone. There is no direct evidence that soy pose a problem for subclinical hypothyroid patients and research specifically addressing this issue is currently underway. The second situation involves individuals whose iodine intake is marginal or inadequate. Some subpopulations may not be consuming sufficient iodine, such as women of reproductive age and vegetarians, and especially vegans, who do not use iodized salt, may be at increased risk of developing iodine deficiency. Consequently, vegans need to been especially mindful of their iodine intake, especially because they are often high-soy consumers (Messina, 2011). Research on humans indicates that you need not avoid soy if you experience hypothyroidism, as long as you are getting iodine either in your diet or through a supplement.

7. Properties of soy proteins in relation to different population segments

Isolated soy proteins are intermediary fast proteins, which favour both the building of muscles and the maintenance of other bodily functions

The motivation for consuming soy proteins strongly depends on the needs and desires of the individual consumer. Some eat soy proteins to benefit from the many health promoting and disease preventing properties of soy. Others eat soy to build or restitute muscle tissue after sports or training. Some use soy proteins to gain or lose weight after disease, malnutrition, loss of appetite or obesity. Others eat soy because of religious or ethical considerations. Some eat soy to evade allergies towards other food sources. And finally, some eat soy simply because they find the taste appealing and like to occasionally substitute other proteins sources with soy protein.

Bodybuilders and sportsmen In order to deliver peak performances or reduce the fat percentage in the body, many bodybuilders and sportsmen live by strictly controlled diet patterns, and many utilize protein powders as the main source of proteins. The primary origins of the proteins are from milk-whey or -casein, egg, meat or soybeans. Many investigations have evaluated the difference in efficiency of the different proteins types on particularly stimulating the “Muscle Protein Synthesis” (MPS) after exercise (e.g. Tang et al., 2009; Diebert et al., 2001; Reidy et al., 2012). The overall conclusion of the investigations is that the speed of digestion and amino acid absorption, and the amino acid composition of the protein sources play a major role on the resulting muscle assimilation. “Fast” proteins, such as milk-whey are slightly superior in promoting synthesis of skeletal musculature, but inferior in overall protein assimilation in the rest of the body. “Slow” proteins, such as meat- and egg-proteins favour the overall protein assimilation over muscle assimilation. ”Intermediary” fast proteins, such as milk-casein and isolated soy proteins favour both the building of skeletal muscles and the maintenance of important organs such as intestines, liver and skin (Reidy et al., 2012; Yang et al., 2012; Deibert et al., 2011).

Weight gainers Some people have an acute need of gaining weight or maintaining a sufficient blood level of amino acids, but lack appetite or motivation to eat. These include anorectics, weak elderly people, hospitalized people, chemo patients, malnutritioned children, people with dysfunctional digestion or metabolism, etc. For many of these groups the lack of appetite or efficiency of amino acid uptake means that the ingested does not meet the demand of the body, and it is thus important to get a god “value for money” of the little food, which is actually ingested. Compared to fat and carbohydrates, proteins have a tendency of inducing a feeling of satiety and lack of appetite for more food (König et al., 2012; Lang et al., 1998; Veldhorst et al., 2009; Alfenas et al., 2010). For this purpose isolated “intermediary fast” proteins, such as soy proteins will serve as a concentrated source for complete protein. For hospitalized elderly patients the risk of secondary complications is high, and a study comparing the use of casein and soy as enteral protein sources concluded that soy proteins significantly reduced the risk of ulcers, intestinal complications and death as compared to casein (Espín et al., 2010). Soy protein has a high content of the amino acid leucine, which has proved to be a significant factor in the muscle building and weight gain of recovering cancer patients (Deutz et al., 2011).

Weight loser Obesity is a problem to an increasing number of people. Eating fat reduced, fibre-rich products, such as isolated soy proteins have the obvious advantage that the fat intake is reduced, as compared to e.g. meat. Soy proteins have been shown to induce the feeling of satiety faster than other protein sources such as casein and whey, thus reducing the further food intake (Alfenas et al., 2010). The rise in glycemic and insulinemic load gives good indications of the speed by which the blood sugar rises after the ingestion of a meal. A too fast rise in the loads of the blood will increase the risk of energy being allocated to storage (e.g. fat) rather than metabolic processes, resulting in a possible weight gain. Breakfast containing isolated soy proteins in comparison with a standard breakfast has been demonstrated to result in a significantly lower glycemic load (König et al., 2012).

Vegetarians Vegetarians and vegans have chosen to primarily base their food intake on plant derived food. This presents a challenge of obtaining all the necessary amino acids in adequate amounts, as some amino acids are relatively rare in plants. Isolated soy protein is a “complete protein” and thus provides all the essential amino acids. However, some soy products do also present certain challenges, as e.g. the phytic acid content may interfere with the uptake of minerals. Isolated soy proteins contain a very small amount of phytic acid and a normal mineral uptake is thus easily maintained (Mesina and Mesina, 2010).

People with diseases or disorders Although the established medicinal community is reluctant to recognize the intake of soy as the potential cure and prevention for a wide range of diseases and disorders, a growing number of people consume different soy products for medicinal or prophylactic purposes. Some disorders including hypocholesterol, menopause discomforts, osteoporosis and coronary diseases have been recognised by particularly the American authorities to be decreased by the intake of soy (See also “Health aspects of soy consumption”).

“Normal” people People from East Asia have consumed soy products as part of their staple diet for millennia, and for the past decades people of the rest of the world have gradually increased the intake of soy. A large quantity of the consumed soy is consumed as a “hidden” ingredient in industrially produced food products, infant formulas, etc., but a growing proportion is also consumed because consumers deliberately chose soy over other protein products. Soy may not be the “miracle food” which some American agitators wish us to believe, but it is undeniable that isolated soy protein is a healthy, fat free source of complete protein, which, in many dishes, can replace meat.

Isolated soy protein is a complete protein, and can serve as a healthy primary source of protein for most people.

8. Environmentally sustainable proteins from soy

The production of soy protein has a smaller impact on the environment than animal proteins

Increasing utilisation of plant protein is required to support the production of protein-rich foods that can replace animal proteins in the human diet to reduce the strain that intensive animal husbandry poses to the environment. From a nutritional standpoint, with the right combination, plant proteins can supply sufficient amounts of essential amino acids for human health requirements. Land plants have always been part of the human diet to provide energy and nutrients for sustainable living. Although plant proteins are relatively cheap and more abundant than animal proteins, direct consumption of proteins from land plants in conventional human food is still fairly limited. Currently, most plant proteins are used as animal feed to produce functional animal proteins from milk, eggs and meat (Day, 2013). However, the conversion of plant proteins into animal proteins is relatively inefficient. In some cases, less than 15% of the plant proteins from feed crops are turned into animal proteins for human consumption and 85% are wasted (Aiking, 2011; Pimentel & Pimentel, 2003). As a consequence, meat production is responsible for a disproportionate share of food-related environmental pressure (de Boer and Aiking, 2011; Gilland, 2002). With respect to land use, if the same amount of plant proteins is used directly for human consumption, less than 10% of land will be required to grow food crops as to otherwise feed crops to produce the same amount of meat proteins (de Boer and Aiking, 2011). Furthermore, production of animal proteins requires about 100 times more water than producing an equal amount of plant proteins (Pimentel & Pimentel, 2003). With the rapid growth in the world's population, food security has been seen as the next large challenge for the agrifood industry. Better and more efficient utilisation of plant-based proteins will become critical when the supply of animal proteins reaches maximum production capacity to feed the growing world population. The shift towards a more sustainable diet necessitates less reliance on foods of animal origin, and thus presents an huge potential for the agrifood industry to explore alternative sources of proteins (Aiking, 2011). For example, the development of new meat analogue products has accelerated in recent years, with some of the most promising alternatives based on proteins from plant sources, such as soybean and peas, and the dairy substitutes market has also expanded. Plant protein-based meat and dairy substitutes can deliver equivalent quality at lower costs, while fulfilling the world's priority of reducing greenhouse gas emissions and limiting destruction of forest land (Dijkstra et al., 2003; Linnemann and Dijkstra, 2002). In addition, the right combination of plant proteins can ensure the supply of sufficient amounts of essential amino acids for human health requirements.

Soybean is one of the most important agricultural commodities because of its high protein content which is about 35–40%. Soybean is the dominant oil seed crop worldwide and the second largest source of vegetable oil, after palm oil. Currently, global production is estimated to be about 271 million metric tons per annum (Day, 2013), and a large amount of defatted soybean meal is produced after extraction of oil. Most defatted soybean meal is used for animal feed. A small portion is further processed into various types of soy protein products for human consumption. Although traditional foods made from soybean have been consumed throughout East Asia for more than two thousand years, in Western countries, soybean derived products have only become an economical and high quality vegetable protein source for human diets over the last few decades. Soy's high protein level and well-balanced amino-acid composition makes it an important source of plant protein, with a great potential to replace meat and dairy proteins in our daily diet (Day, 2013).

Soy4you® and Soy4you øko® is produced in such a way that they can replace meat in many daily dishes

9. References

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