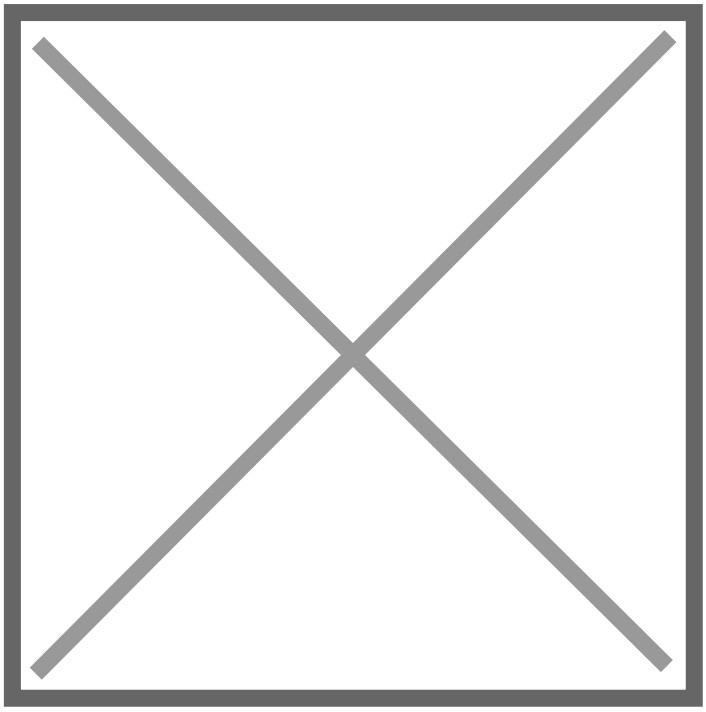
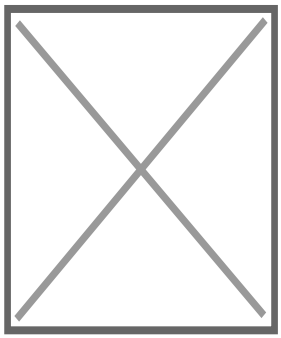
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Catalysts for Success

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Catalysts for Success

There is a lot of potential to develop bioactive compounds and related functional foods and nutraceutical products from cereal, oilseed, legume, and other crops.

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T he approach to utilization of crops has traditionally been from a food perspective, but changes which are occurring in legislation and regulations in Canada and around the world are leading to a more holistic, health promotion perspective regarding the value of these crops. It is recognized that many of the secondary metabolites of these plants have therapeutic and health-promoting properties. Under US legislation, many of these plants or their derivatives can be marketed in foods and as supplements, with relevant claims for health-promoting properties. Recently, Canadian regulations have permitted disease risk-reduction claims on five food extracts with proven physiological value.

Consumers and regulatory agencies are demanding scientific evidence for claims made by distributors of functional foods and nutraceuticals. Currently, there are products that are being marketed based on anecdotal information or on very limited research. Such products have the potential to create serious danger to consumers through interactions with prescription or non-prescription medications or through over-consumption. Other products have significant potential for health benefit and also must be shown to be safe, efficacious and of high quality.

Development of these functional foods and nutraceuticals will require interdisciplinary research involving experts from: (i) food sciences and nutrition to identify and isolate novel bioactives and to develop food and health products that incorporate these

ingredients; (ii) food chemistry to determine the structural/molecular basis for physiological activity and to evaluate potency and functionality in food formulations; (iii) engineering to develop innovative processes for extracting bioactives; (iv) plant science to enhance the bioactives using plant breeding and genetic engineering; (v) medicine, animal, and human nutritional sciences to conduct basic research in defining the pathways of utilization of bioactives by the cell, animal, and human systems, and assessment of health benefits; (vi) pharmacy to conduct research on the development and evaluation of new products for promoting the health of consumers and on possible reactions with pharmaceutical agents; and (vii) human nutritional and food sciences to conduct consumer sensory testing and education. Such integrated research is needed both for the growth of the functional foods and nutraceuticals industry and to provide efficacious and safe products to consumers in Canada and throughout the world.

Identification of Bioactives

Most crops as excellent candidates for value-added processing as functional foods and nutraceuticals. Some example crops are: oats, wheat, and buckwheat, for their non-starch polysaccharide components; and canola, flax, borage, and hemp seed, for their fatty acid components. Complementary expertise in carbohydrate, protein, lipid and analytical chemistry are needed to identify components of interest in plants. It is necessary to identify which molecular features (e.g., composition, substitution groups, polarity and weight) of these biomolecules are responsible for specific bioactive properties, and how functionality is influenced by interactions with other polymers, solvents or solutes present in plant material or in food systems.

Enhancement of Bioactives

Enhancement of bioactives in plants can be done using plant breeding and genetic engineering techniques thus requiring expertise of plant scientists, breeders, and biotechnologists. The research is needed to decide which crop, which variety and which tissue is the best source for recovery of a bioactive. Enhancement could also involve introduction of genes responsible for the bioactive at sites in the plant other than those which occur naturally, without affecting agronomic characteristics, to facilitate higher levels of production, ease of extraction or ease of consumption. Knowledge of the chemical nature of the bioactive will, in many cases, allow the identification of the pathway involved in the synthesis of that constituent. Plant physiologists, with an understanding of the role played by that constituent in the plant, will determine if the pathway can be successfully "up-regulated" to allow greater production of the bioactive without negatively affecting plant productivity. This up-regulation can be achieved by evaluating the natural variation that exists within the population for selection within a conventional breeding program. Alternately, a genetic engineering approach could be used to modify the expression levels of critical steps in the pathway.

Development of Functional Foods

At the present time, food and bioprocessing are largely developed by empiricism and trial-and-error. There is an urgent research need to develop quantitative and systematic engineering approaches for scaling up processes and for efficient and cost-effective processing of biomaterials. This kind of research is being done on a very limited scale around the world because most research institutes do not have a well equipped pilot plant where such research can be done. Also, such a pilot plant must be supported by well equipped analytical labs. Research is needed on optimization of product formulations, optimization of process parameters, component stability, effective packaging techniques, delivery systems, and quality control methodologies.

Assessment

Establishing the safety and health-promoting value of these nutraceutical products will require studies on the metabolism, pharmacokinetics and pharmacodynamic nature of the active ingredients. Researchers from human and animal nutritional sciences, pharmacy, pharmacology, physiology and other health related expertise must conduct in vitro and in vivo studies to determine these properties for candidate nutraceutical products. Hepatology studies in animals and in ex vivo experiments will be required to obtain additional information on metabolism and kinetic properties. Also, of critical importance is the examination of ameliorative effects of nutraceuticals on known risk factors and markers for the development of chronic diseases such as cardiovascular disease, cancer, osteoporosis, Alzheimer's disease, and type-II diabetes. In vitro studies must be complemented by controlled metabolic studies that will be conducted to specifically measure the in vivo effects of test phytochemical consumption on biochemical markers/risk factors for several diseases. The research team must have access to numerous animal models of chronic diseases to evaluate the effectiveness of phytochemicals on slowing the progression of these diseases. The assessment of bioactivity in animal models is critical for the identification of candidate phytochemicals to be tested in human clinical trials. Consumer related research will also be required to ensure that functional food and nutraceutical products meet the requirements of taste and fit with lifestyle and culture.

Research Coordination

Research projects may begin at various points depending on what is currently known about specific bioactive phytochemicals. For example, if only the beneficial health properties of a food are recognized but the responsible bioactive is unknown, then work could begin at the analytical level to identify the responsible agent. This type of project would progress through analysis and characterization in the analytical labs but would also involve feeding or clinical tests at various stages to ensure the bioactive compound is being followed successfully.

Once the bioactive constituent is identified, and a specific technique for quantifying the constituent is developed, the project material and information on bioactive characteristics must be passed to a team involving food scientists and food engineers to develop pilot scale procedures for enrichment and/or extraction of the bioactive from the source material. This stage might again involve feeding trials or clinical work to look at bioactive stability during processing. If a nutraceutical product were the goal and a pilot plant scale process can generate a pure or an enriched form of the bioactive, this product could be provided to other researchers with expertise in: (i) assessing safety through feeding studies and; (ii) pharmacokinetics/pharmacodynamics, to study the metabolism of the bioactive.

Assuming a range of safe consumption can be identified, the material could then be tested for its health-promoting benefits as a nutraceutical in clinical trials. Once the health- promoting value of an identified bioactive, in either a functional food or nutraceutical is confirmed, and its potential value as a commercial product identified, plant scientists could use their expertise to assess alternative plant and cultivar sources of the bioactive.

Depending on the limitations of bioactive yield provided by the available source, a decision would be made as to the feasibility and implications of enhancing the bioactive in the available or alternative plant source. In cases where a beneficial bioactive constituent is known, it could enter the development stream at various points and advance through it according to the information available.

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