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Emerging Food Products, Technologies and Processes: Insights for Regulators

Food Regulatory Issues Division
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Canada

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Introduction

To be productive and competitive in a global marketplace, Canada's agri-food sector invests in science to develop innovative food products, technologies and processes. It is important for the sector to consider the regulatory system when making decisions on investment, product development and marketing. In turn, the regulatory system must be responsive to accommodate these advances; regulators need to know where to allocate resources and prioritize efforts to achieve the greatest benefit.

The foresighting project described in this report was undertaken by the Food Regulatory Issues Division of Agriculture and Agri-Food Canada (AAFC), in collaboration with the Food Directorate of Health Canada. An environmental scan of published literature was conducted to identify emerging innovative food products, technologies and processes that could enhance food safety, nutritional composition or health attributes and that may have implications for the regulatory framework, including pre-market approval (e.g. novel foods, food additives or health claims) by Health Canada over the next 10 years. The findings were then validated and refined through engagement exercises with selected stakeholders in Canada's agri-food sector.

Ultimately, the information in this report aims to help regulators proactively anticipate and assess the need to develop or modify regulatory requirements associated with emerging innovations and identify research gaps.

Methodology

An environmental scan was conducted to identify a representative sampling of emerging innovations domestically and abroad. The scan focused on publicly available published and "grey" literature, including research networks, presentation content and press releases from recent scientific conferences and workshops, scientific publications, and informative web portals. Results were organized into categories to identify emerging trends. The preliminary report included a description of each relevant search result, its identified stage of commercialization and why the product/technology is considered novel and/or has other regulatory implications. The report also included information on potential future health claims in Canada.

Stakeholder feedback was elicited during March 2012 to: gauge interest in and establish priorities for the emerging innovations identified by the environmental scan; identify any additional emerging issues; and identify challenges with the pre-market regulatory approval process for these emerging innovations.

Stakeholders were selected based on their expertise and experience in the area of interest. The two types of validation exercise undertaken were a webcast session and four in-person sessions at regional food technology centres (Portage la Prairie, MB; Boucherville, QC [French]; Guelph, ON; and Charlottetown, PEI). The findings of the scan were presented to participants and a questionnaire was used to collect feedback. The webcast also included polling questions and a question-and-answer session; the regional sessions included verbal discussions.

In total, 81 stakeholders participated and 68 questionnaires were received. Input based on business and technical knowledge of the emerging innovations came from food processing companies and food manufacturers, along with research or technical development organizations, consultants, non-profit organizations, representatives from AAFC regional offices, other federal departments, provincial governments and universities/colleges. The results reported are based on overall stakeholder feedback unless otherwise indicated.

Search Results and Stakeholder Feedback

The review of the publicly available search portals identified 313 emerging trends in novel food products, ingredients, technologies and/or processes. As shown in Figure 1, the findings indicate a focus on innovation in eight areas.

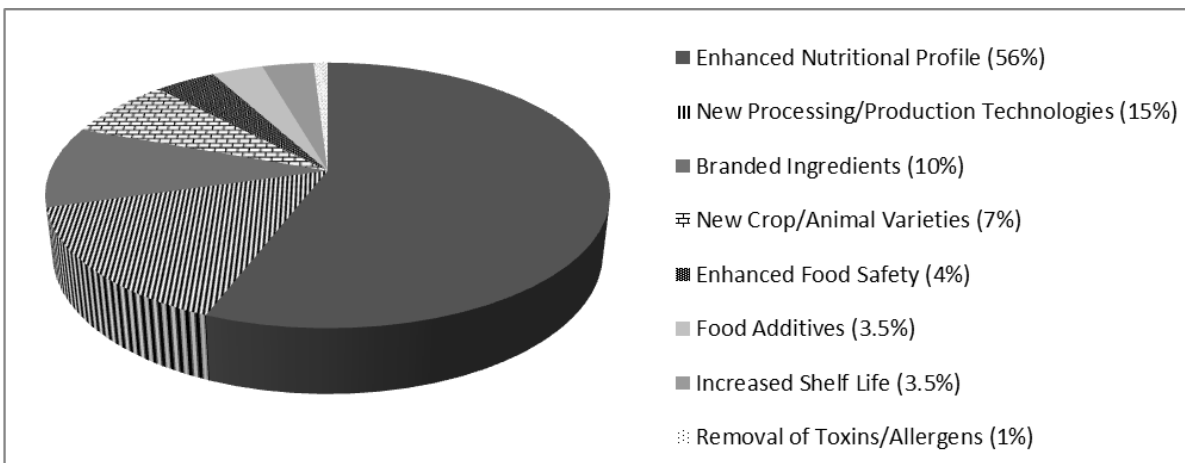


Figure 1. Categories of Emerging Food Products, Technologies and Processes

In general, agri-food stakeholders agreed that the categories and sub-categories of food products, technologies or processes described by the environmental scan were emerging issues, and could have regulatory implications.

Future Importance

In terms of the future importance of these eight categories of innovation:

- Stakeholders indicated that three categories will have **greater importance** in the future: foods or technologies for *Enhanced Nutritional Profile/Enhanced Nutrition*, *New Processing and/or Production Technologies* and *Enhanced Food Safety*.
- Branded Ingredients*, *Removal of Toxins/Allergens*, *New Food Additives*, and *Increased Shelf Life* were identified as categories that will have the **same level of importance** in the future.
- New Crop or Animal Varieties* was identified as a category that will have **less importance**.

Although the trends were similar between the webcast and the regional sessions, regional participants tended to rank *Branded Ingredients*, *New Food Additives* and *Increased Shelf Life* as having lower future importance. All regional groups except PEI ranked *Enhanced Nutritional Profile* as number one, on average; PEI ranked it in second place, and ranked *Enhanced Food Safety* first.

Participants in the webcast session indicated two additional emerging categories of innovation regarding food products, technologies or processes: the use of branded ingredients for nutritional functionality in Canadian foods, as well as use of 'natural' or 'naturally sourced' foods or ingredients.

Some stakeholders mentioned that considering the Generally Recognized as Safe (GRAS) status of food ingredients in the U.S. would be useful as a good measure of the regulatory significance for emergence in Canada.

Enhanced Nutritional Profile/Enhanced Nutrition

Of the 313 total search results, 175 (56%) were classified as products, technologies or processes related to *Enhanced Nutritional Profile/Enhanced Nutrition* (see Figure 2).

Findings allocated to this category included innovations that would improve the nutritional profile of foods, whether through inherent technologies such as feeding practices at the production level or through the addition of bioactive ingredients into traditional food formats. The following innovation sub-trends were observed within this category:

- **Addition of New Ingredients to Foods** (e.g. probiotic cheese, wholegrain baked products with lutein). Overwhelmingly, most search results were specific to this sub-category of innovation. “New” often meant adding bioactive ingredients (e.g. lutein, algae, chlorella, docosahexaenoic acid [DHA], conjugated linoleic acid [CLA], luteolin, theanine, glutamine) to conventional foods for a desired health effect.
- **Inherently Enhanced Animal Products** (e.g. DHA-enriched bacon, omega-3 enhanced chicken and pork). Results allocated to this sub-trend included the feeding of animals with an unconventional feed as a means of increasing the nutritional composition of the subsequent animal food product. Examples from the search results involved soybeans, lobster meal, flax co-extruded with field peas, and barley with vitamin E.
- **New Food Source/New to Canada**. This sub-trend included certain foods not typically used or considered ‘conventional’ in Canada (e.g. ice cream from human breast milk) or foods that are traditionally grown in other jurisdictions but are not readily available in Canada (e.g. camel milk, bamboo, purple carrot).
- **Novel Fibre** (fibre from asparagus spears, from pea (*Pisum sativum*) and from apple skins).
- **Improvement in Food Properties** (quality and organoleptic properties of lean meats).

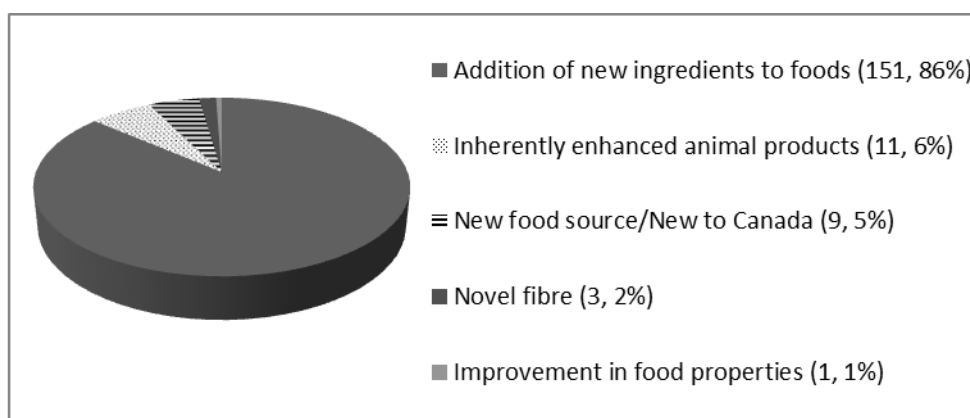


Figure 2. Sub-Trends in Enhanced Nutritional Profile/Enhanced Nutrition

Overall, emerging innovations allocated to this category were in a variety of stages along the commercialization pathway, including laboratory investigations, preclinical and clinical studies, as well as actual product launches in other jurisdictions.

Relevance

Agri-food stakeholders indicated that all of the sub-categories were emerging innovations. For the purposes of regulatory prioritization, *Addition of New Ingredients to Foods* was the sub-trend most relevant to their organizations. Participants in the regional sessions identified the sub-trend of *Inherently Enhanced Animal Products* in second place, whereas webcast participants identified it as least relevant.

Regional participants commented that *Addition of New Ingredients to Foods* and *Improvement in Food Properties* were not “emerging” as these practices are ongoing. Regarding *Inherently Enhanced*

Animal Products, some regional participants mentioned the importance of coordinating with the *Feeds Act* administered by the Canadian Food Inspection Agency (CFIA).

Additional Innovations

Webcast participants identified the following as additional emerging agri-food innovations specific to *Enhanced Nutritional Profile/Enhanced Nutrition* that had not already been identified:

- Resistant starch to improve insulin sensitivity
- Walnuts may boost memory, improve cognitive function
- Cherries, particularly sour or tart cherries, have high antioxidant content and potential benefits in terms of reducing inflammation, painkilling properties, and improving sleep quality
- Baby formula with added prebiotics and probiotics
- Ginger may improve cognitive function in women
- Consuming fruit high in fibre may promote dental health in older men

Regional participants raised questions about the regulatory implications of consuming larger quantities of bioactives in foods, consuming foods containing nutrients and bioactives modified in size (levels undetectable or unquantifiable with the current techniques) and classification of particles with respect to nanotechnology. They also mentioned the need for increased emphasis on bone health and on inflammation as an underlying factor for many chronic diseases.

Specific products mentioned were sweet white lupin, resistant starch and meal/cake for novel fibre products, and products from high pressure processing. The Quebec group also noted the absence of “natural health products” (NHPs) being considered here, and indicated that consumers do not differentiate between NHPs and food products, when it comes to added ingredients (e.g. stevia). They indicated that this adds confusion for the consumer, in terms of safety vs. health benefits.

Health Context

As shown in Figure 3, the majority of search results allocated to the category *Enhanced Nutritional Profile/Enhanced Nutrition* had been developed or were undergoing development in support of chronic health conditions and overall wellness, particularly with respect to cardiovascular disease and diabetes (33%), aging (22%), and personalized nutrition¹ (18%).

Stakeholders’ ranking of interest in health categories as they pertain to innovative food products or technologies were consistent with these findings, with an emphasis on cardiovascular disease and diabetes, ahead of aging for webcast participants and cancer for regional participants.

This issue resulted in a broader range of responses between regional sessions. Some participants indicated that all of the health conditions are important, with different factors dictating the focus on one over another. In Ontario, unlike the other regions, most conditions were ranked very similarly for interest. Manitoba participants ranked immune function higher than the other regions. Other concerns mentioned by regional participants included glycemic control, satiety, and bone and joint health.

¹ For allocation purposes, ‘Personalized Nutrition’ was defined as products/technologies specific to a certain sub-population with specialized wants/needs (which did not necessarily pertain to the other defined health categories). It included nutrigenomics as well as foods targeted to specific lifestyle choices such as religious diets or restriction of specific nutrients.

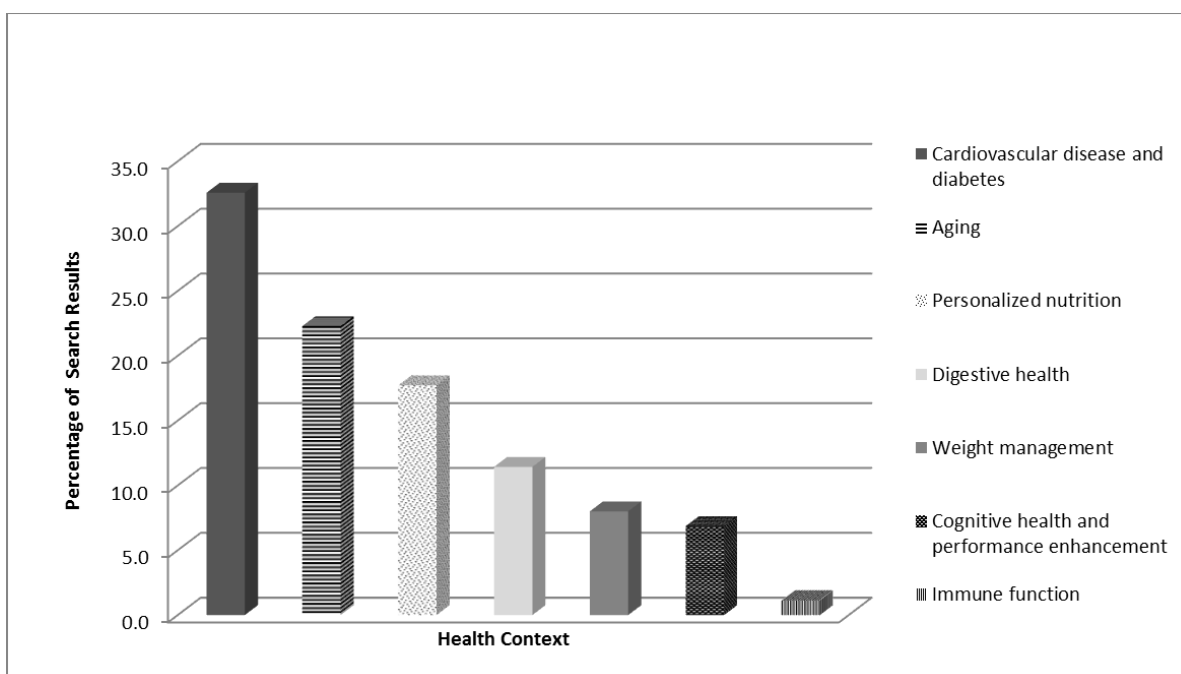


Figure 3. Enhanced Nutritional Profile Innovations with a Health Context

Potential Health Claims

As part of the environmental scan, potential food–health relationships for the Canadian agri-food sector were identified which, if substantiated, could lead to future health claims that can benefit consumers. The selections were made based on the composite analysis of global trends, marketplace information, Canadian sector capacity and, to a lesser degree, the level of supporting evidence.

Not surprisingly, the resulting observations (Table 1) are consistent with the conditions targeted by the innovations in the category of *Enhanced Nutritional Profile/Enhanced Nutrition*. Health outcomes such as blood glucose control, digestive health, immune health, satiety, cardiovascular disease (CVD), cancers, as well as age-related conditions such as macular degeneration, arthritis and dementia may be responsive to various foods or food constituents that can be delivered by the Canadian agri-food sector.

Table 1: Potential Food–Health Relationships Presented to Stakeholders for Discussion

Health Condition	Food or Food Constituent
Dementia, CVD, cancer, age-related macular degeneration, rheumatoid arthritis, osteoarthritis	Omega-3 fatty acids
Age-related macular degeneration	Carotenoids (such as lutein and zeaxanthin)
Some types of cancers	Selenium and Vitamins C and E
CVD, post-prandial glycaemic control, long-term blood glucose control, satiety, chronic constipation	Dietary fibre
Digestive health, colonic function, immune support	Prebiotics, probiotics (certain strains of microorganisms)
Antibiotic-associated diarrhea (AAD)	Probiotics
CVD, post-prandial glycaemic control, long-term blood glucose control, digestive health	Pulses, whole grains
CVD, post-prandial glycaemic control, long-term blood glucose control	Plant oils (such as flax, canola and hemp)
Antioxidant status, immune support	Fruits and vegetables
CVD, immune support, satiety	Proteins and peptides (derived from plant and animal sources)

Stakeholders mentioned anti-aging products or ingredients and foods providing sustained energy and satiety as food–health relationships of interest. One participant said that the area of “inflammation” should be included on this “health condition” list, particularly as the science is in its infancy.

Function Claims

When asked what new (nutrient) function claims are of interest to their organizations, stakeholders identified the following bioactives and their intended functions:

Table 2: Potential Future Function Claim Topics of Interest to Stakeholders

Nutrient or Bioactive	Intended Function
Antioxidants Berries (e.g. Saskatoons)	Reduction of oxidative stress in cells; impact on various diseases/conditions
Lutein	Eye health
Omega 7 (Palmitoleic acid) Carotenoids Natural vitamins	Cardiovascular disease Skin health
Vitamin D enrichment of meat	Cancer prevention
DHA enrichment	Cognitive health
Fibre Protein (vegetable, animal)	Satiety, hunger sensation
Oat/barley beta-glucan, fibre	Diabetes, blood sugar control
Resistant starch	Digestive health / Satiety
Pro-anthocyanins	Urinary tract infections Prevention of dental plaque
Anthocyanin Resveratrol	Improved cardiovascular function
Fruit extracts	Metabolic syndrome and diabetes
Vegetable extracts	Immune system function

When polled, seven out of eight webcast respondents indicated that health claims are *very important* or *somewhat important* for their organization’s product marketing.

Regional participants also mentioned that omega-3 (claims) and folate (status) were of interest. Barley beta-glucan was mentioned; a lot of research and work has been done but no claim has been approved. One company indicated health claims were not very important; however, several participants commented that nutrient and other health-related claims are very useful for marketing purposes. In general, participants commented that pre-market regulatory approaches were cumbersome or that companies had products with functional ingredients they would like to highlight but currently cannot. Some participants suggested that harmonization with U.S. or other recognized scientific bodies would simplify expedition of health claim approvals.

New Processing and/or Production Technologies

Following *Enhanced Nutritional Profile/Enhanced Nutrition*, the greatest number of search results (46, or 15%) were allocated to the category of *New Processing and/or Production Technologies* (see Figure 4). This category was further separated into the following sub-trends:

- **Extraction Methods/Ingredient Processing.** Examples include oil-to-powder technology to convert oils into free-flowing powder without affecting structure, colour or taste; nocturnal milk production to increase melatonin content; development of water-soluble lipids for addition to foods and beverages; and pulsed ultraviolet (UV) light to improve nutritional content of mushrooms and fungi.
- **Enhanced Delivery Systems/Functional Aspects.** Generally, technological innovations in this sub-trend focused on enhanced delivery of bioactive ingredients (e.g. nanoemulsions, probiotic pellets, microencapsulation to improve the survival of probiotic cultures), or enhanced functional aspects of foods (e.g. inhomogeneous spatial distribution of fat and sugar to enhance perception of tastants and fat; development of organogels).

- **Genetic Manipulations.** This sub-category included technologies such as cloning, stem cell research and breeding techniques (e.g. improved genetic testing for breeding of more tender beef, foods from cloned animals and the offspring of cloned animals, lab-grown meat).
- **Sanitation and Safety.** Examples of innovations include ultrasonic techniques for reduced microbial growth, nanoagriculture technology to deliver genetic materials to plants or to target pesticides more effectively, and novel packaging techniques such as modified atmosphere technology to extend shelf life.

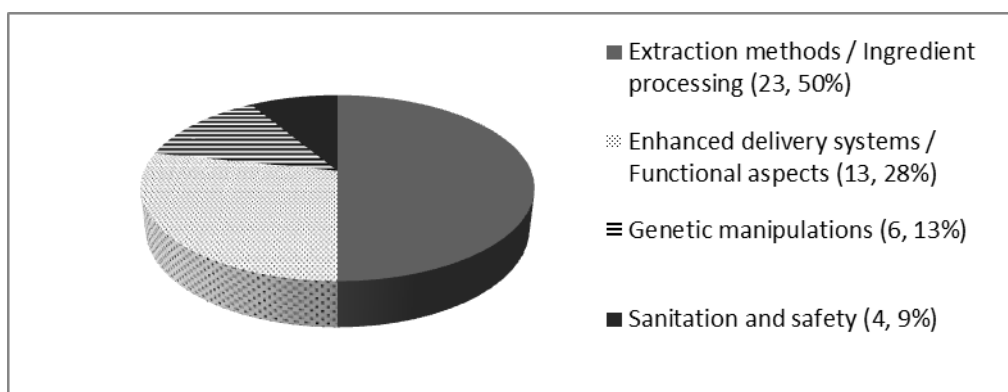


Figure 4. Sub-Trends in New Processing and/or Production Technologies

Two thirds of the search results allocated to this category were in the experimental stages of the commercialization pathway.

Stakeholders generally agreed that these sub-trends were areas of emerging innovation, with somewhat more importance allocated to *Extraction Methods/Ingredient Processing* and *Enhanced Delivery Systems/Functional Aspects* than to the other sub-categories.

For regulatory implications, webcast participants chose *Extraction Methods/Ingredient Processing* as the most relevant sub-trend whereas regional participants indicated *Genetic Manipulations*. Although stakeholders generally agreed that *Genetic Manipulations* have regulatory implications, many did not consider this to be an emerging innovation.

In terms of missing technologies, regional participants mentioned high pressure processing, along with pulsed electric field, ultrafiltration, ohmic heating and microbial enzymes. Some participants commented that they were not sure whether certain innovations would be included here or under other categories (e.g. not knowing if high pressure processing would be included under *Sanitation and Safety*). A specific example regarding a processing innovation with safety and regulatory considerations was microfiltration of milk and the effort to use this as a replacement for pasteurization. Microfiltration is not considered emerging, per se, but using this technology as a pasteurization replacement would be novel, and it was unclear if this is what was intended with the *Sanitation and Safety* sub-category. The same could be true for technologies (newer to Canada, like high pressure processing) that would have safety or regulatory requirements. However, it was stated that not all of the missing 'novel' technologies would have regulatory implications. In general, most participants at the regional sessions commented that classification under this category did not necessarily concur with industrial practices and that "processing" is an important category on its own, with a lot of interest and activity within industry on new or emerging processing technologies.

Branded Ingredients

Of the 313 total search results, 31 (10%) were classified as *Branded Ingredients*. Examples include branded fibres, sweeteners, plant extracts, proteins, prebiotics, antioxidants and technologies. No further trend analysis was possible given the variability within this category. For industry, branding may serve to protect intellectual property investment into technologies or product formulations, and can assist with quality assurance measures. Branding of products, ingredients or technologies may

also enhance consumer recognition and/or loyalty. Two thirds of the 31 innovations were launched or approved for use in other jurisdictions.

Stakeholders generally agreed that this was a category of emerging innovation. However, they did not always agree that this category had regulatory implications; some regional participants, particularly in the PEI session, considered that branded ingredients would be more of a marketing than a regulatory concern, unless a declaration or a nutrient or health claim were expected to be made. Similarly, the Ontario group commented that branding can be a way to gain exclusivity, which indicates marketing advantage, but not necessarily regulatory advantage.

Regional participants cited examples of existing successful branded ingredients or products, including stevia, Benecol and Activia. In terms of missing technologies, camelina, calendula and omega-3 (Meg3) oils were cited as emerging oils. Seabuckthorn was given as one example that could be branded as an antioxidant if it became possible to highlight this health effect.

Overall, the concept of a branded ingredient may have more relevance to a sub-sector of the industry (e.g. ingredient suppliers) than to food manufacturers, who would not be involved in the development or regulatory process of branded ingredients.

New Crop and/or Animal Varieties

A total of 23 innovations (7%) were categorized as *New Crop and/or Animal Varieties* (see Figure 5). Innovations in this area may be of increasing interest due to factors such as climate change and population growth. As such, the new crop varieties identified in the search were bred to withstand extreme weather conditions and/or to provide a greater yield with enhanced nutritional properties.

The results were almost equally distributed between the following sub-categories:

- **Improving Inherent Nutrient Content**, with innovations in the following areas:
 - Development of crop cultivars/varieties with enhanced levels of bioactive constituents (e.g. phenolics in berries, glucoraphanin in broccoli, rutin antioxidant in asparagus);
 - Advances in breeding to improve bioaccessibility and bioefficacy (e.g. provitamin A carotenoids in maize); and
 - Growth of 'tailored foods' (e.g. to maximize the genetic profile for fat metabolism in ethnic populations).
- **Improving Crop Survival or Yield**, with innovations in the following areas:
 - Gene discovery (focusing on plant survival under conditions of drought and cold);
 - Performance plants (with resistance to heat, pests and disease, improved water efficiency and/or increased biomass);
 - Increase in leghemoglobin (plant hemoglobin) to improve survival and production under extreme environmental conditions); and
 - Selective breeding for optimal animal products.

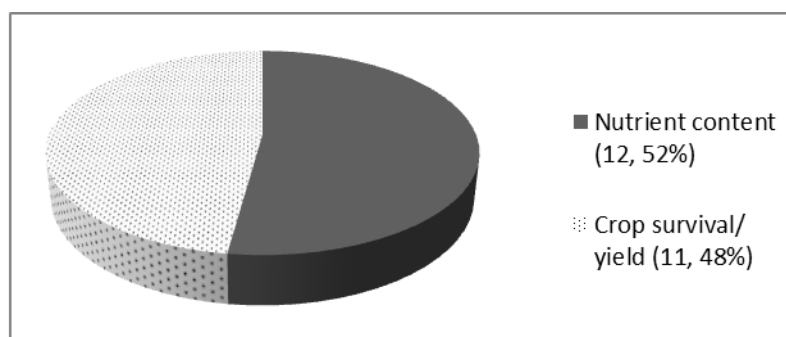


Figure 5. Sub-Trends in New Crop and/or Animal Varieties

Almost all of the innovations were in the experimental stage in the commercialization pathway.

Stakeholders generally agreed that the sub-trend of *Improving Inherent Nutrient Content* was an area of emerging innovation, and many agreed with potential regulatory implications. However, they disagreed on whether *Improving Crop Survival/Yield* was an area of emerging innovation. Participants in the regional sessions suggested that traditional horticultural breeding provides only modest variations in nutrient profile for emerging products, which would not have regulatory implications. It was also pointed out that applications of biotechnology in the food sector do not always result in foods containing modified genetic material. Some mentioned that horticulture has many successful examples of foods with genetic modification that have not required Health Canada approval and suggested that this system could be the model for other regulatory approvals.

Not surprisingly, stakeholders indicated that *Improving Inherent Nutrient Content* was the most important sub-trend within this category of innovation. This sub-trend was also considered most relevant by agri-food stakeholders for the purposes of regulatory prioritization.

Enhanced Food Safety

Food safety remains a top priority for governments and consumers. Of the 313 total results retrieved, 13 (4%) were classified as novel food products or technologies pertaining to *Enhanced Food Safety* (see Figure 6). Within this category, three sub-trends in innovation were observed:

- **Contaminant Detection.** Examples include x-ray irradiation to improve microbiological safety of vacuum-packed asparagus; natural extracts, such as red cabbage, for antimicrobial action; antagonistic and lytic bacteriophages to control microbial growth; nanotechnology for detection of contaminants; and a melamine analyzer for detecting adulteration of protein-based foods.
- **Monitoring/Preventing the Deterioration of Food Products,** with an emphasis on portable technology. Examples include Radio Frequency Identification for meat transport, as a wireless, automated way to capture data using radio-frequency electromagnetic fields (e.g. potential for monitoring temperature and humidity to prevent deterioration and ensure safety and traceability); and universal serial bus (USB) temperature monitoring as a cost-effective way to determine food safety and quality during and after transit.
- **Labelling.** Printable electronic food labels have the potential to attract and inform consumers (e.g. communication of cautions or warnings, indicators of temperature and freshness, cooking instructions, serving size).

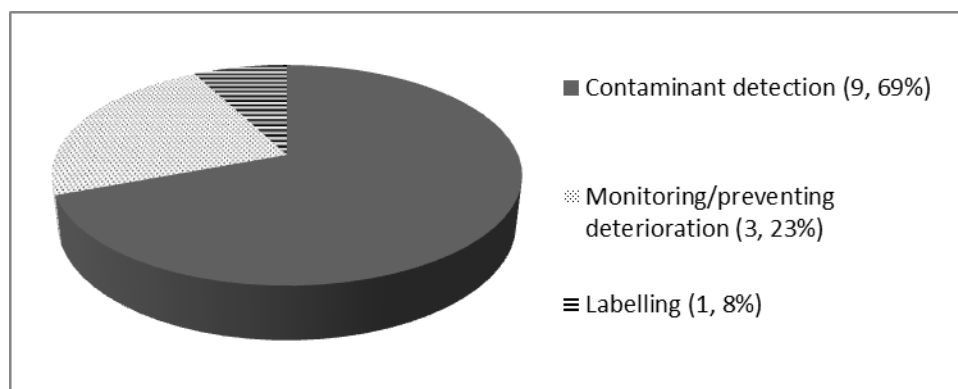


Figure 6. Sub-Trends in Enhanced Food Safety

The 13 results in this category were at varied stages in the pathway to commercialization, ranging from experimental stages to clinical studies completed globally (e.g. Australia, New Zealand).

Agri-food stakeholders generally agreed that the sub-trends of *Contaminant Detection* and *Monitoring/Preventing Deterioration* were areas of emerging innovation, with *Contaminant Detection* identified as being the most important. However, they tended not to agree that labelling was an emerging sub-trend, although having regulatory implications. It was also noted that “control” of contaminants (or potential contaminants) was a missing sub-category.

Stakeholders also considered the sub-trend of *Contaminant Detection* to be most relevant in terms of regulatory prioritization. Regional participants indicated that the innovations in all three sub-trends would have regulatory implications for CFIA rather than for Health Canada. Again, it was raised that these are not “new” per se; for example, monitoring is ongoing (and responsive to emerging threats, such as from China) and labelling with respect to food safety is not relevant (not used by companies). Heavy metals and carry-over solvents were also cited as causes of concern. However, it was mentioned that the regulatory standard of “no detectable limit” has implications; regulatory definitions have not kept pace with analytical measuring capabilities. For example, gluten and lactose can be detected at very low levels, but the regulations do not reflect this ability.

New Food Additives

Eleven results (3.5%) were classified as products or technologies related to *New Food Additives* (see Figure 7). These results could be further separated into four sub-trends:

- **Functional Ingredients.** This group includes substances that impart a function, such as an emulsifier or thickener. Examples of innovations are the inclusion of pea ingredients in sausages to improve their texture, Habo Monoester P90 – vegetable based fatty acids as an emulsifier, and rice bran and soy protein concentrate as a fat replacer in mayonnaise.
- **Sweeteners** (stevia, advantame, tagatose). These are used to sweeten foods without contributing appreciably to the caloric value.
- **Colours** (natural pink colourants from beetroot and paprika, and red colourant from tomato lycopene). Colouring agents can give foods a more appetizing appearance, compensating for unattractive or unfamiliar food colour due to factors such as processing, storage and seasonal variation.
- **Flavours** (natural citrus flavours to quench thirst, launched in Western Europe, South Africa and the Middle East). This sub-trend was included even though the definition of a food additive in Canada does not include flavours because this is not the case worldwide.

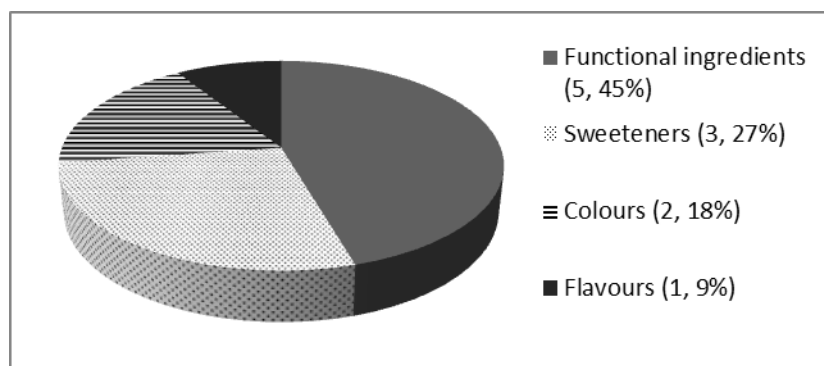


Figure 7. Sub-Trends in New Food Additives

Food additives are essential to product stability and consumer acceptability. However, to maintain acceptability, a trend toward the use of ‘natural’ sweeteners (e.g. stevia) and colourants (e.g. lycopene) could be seen in the environmental scan.

The 11 results in this category were at varied stages in the commercialization pathway, ranging from experimental stages to clinical trials, to product launches in other jurisdictions (including the U.S., Australia, the Middle East and South Africa).

Stakeholders generally agreed that *Functional Ingredients* were an emerging sub-trend in this category of innovation. In fact, it was identified as the most important of the sub-trends in terms of emerging innovations. It was also identified to be the most relevant sub-trend for the purposes of regulatory prioritization. Numerous stakeholders disagreed, however, that *Sweeteners*, *Colours* and *Flavours* were emerging sub-trends within the *Food Additive* category of innovation.

Regional participants indicated that the category overall is not considered to be significant but could trigger regulatory implications if declarations were included on the product label. It was recommended that antioxidants, if listed, should be classified as natural or synthetic. Stevia was mentioned again, along with potato-based sweeteners and vegetable proteins in meat, as missing or interesting additives. There were also comments about the way additives are categorized now (by function and foods in which they are permitted). This has led to some confusion, particularly with multi-functional ingredients, and some stakeholders questioned if this categorization (and resultant confusion) would continue with other “functional ingredients” (e.g. potassium diphosphate as both emulsifier and pH adjuster in dairy products). Again the issue was raised in Quebec about the differential between ingredients in NHPs and foods, with the comment that these should have equal approval and recognition.

Increased Shelf Life

Of the 313 search results, 11 products or technologies (3.5%) were considered innovations for *Increased Shelf Life* (see Figure 8). Although this category and that of *Enhancing Food Safety* are not mutually exclusive, innovations included in this category focused specifically on the goal of increasing shelf life. Three sub-trends were observed within this category:

- **Preservatives.** Preservatives prevent or delay undesirable food spoilage caused by microbial growth or enzymatic chemical reactions. For example, antimicrobial agents prevent the growth of moulds, yeast or bacteria in foods, while antioxidants slow down the process of fats turning rancid and frozen fruit turning brown. The following five innovations were allocated to this sub-category:
 - Ice-structuring proteins (from winter wheat leaves) to enhance the quality of frozen food and desserts during freezing, storage, transport and thawing;
 - Addition of flax lignans to milk to improve nutrient resistance to oxidation;
 - Gum and hydrocolloids to stabilize dairy products and improve shelf life;
 - Vitamins C and E to increase collagen turnover and improve meat quality; and
 - Rose extract to retain pigments in canned strawberries.
- **Coatings.** Examples of innovations include the application of edible coatings on pre-washed blueberries to increase shelf life, the use of pectin-based coatings to enhance the quality of stored avocados, and the development of edible coatings such as sodium alginate and methyl cellulose to increase shelf life of fruit.
- **Packaging.** Packaging can increase shelf life by offering a barrier of protection for the food contents. The two emerging innovations identified were chitosan coating in combination with modified atmosphere packaging and a high barrier packaging system to control (microbial and sensory) quality of fresh pasta during refrigeration storage, and use of an ethylene strip in strawberry containers to improve shelf life by approximately 50%.

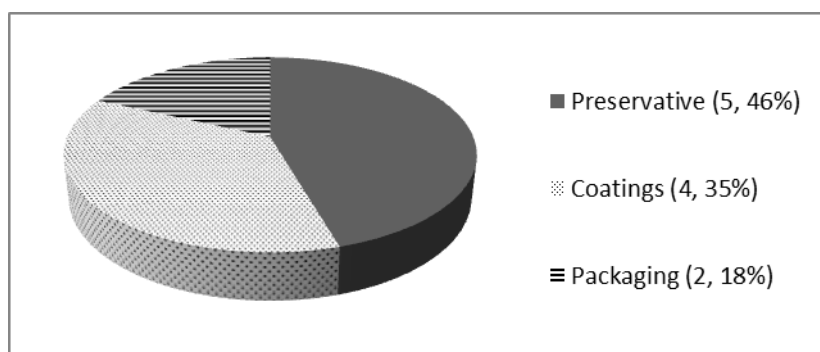


Figure 8. Sub-Trends in Increased Shelf Life

The majority of results in this category remain in the experimental stage of commercialization.

Stakeholders generally agreed that all of the sub-trends were areas of emerging innovation, and had regulatory implications. Webcast participants selected *Preservatives* and *Packaging* equally as the

most important innovation area, whereas regional participants strongly favoured *Preservatives*, with less importance for *Packaging* and almost no importance or interest for *Coatings*.

Regional participants appeared to have some concern about how additives would be considered. For example, an antioxidant could be viewed as a preservative. Likewise, an enzyme added to increase the available resveratrol (e.g. in grapes) could have toxicological implications, as could flax lignans added to milk (as a possible allergen). Bacteriophage research for food safety purposes (e.g. cheese, hot dogs), along with chemical (water/oxygen) absorbers, were mentioned for consideration.

Processing technologies such as high pressure processing were mentioned here again, in the context of extending shelf life (e.g. pasteurized juices in Europe and U.S.). According to participants, the process has to consider the individual product (rather than broader category, such as fruit/vegetable juice), which makes the approval process very costly and cumbersome. Other missing technologies mentioned to extend shelf life included: sterilization by microwave, ohmic heating, radio frequency, pulsed electric field (as mentioned previously) as well as decontamination of surfaces by UV light.

Removal of Toxins/Allergens

The potential for priority allergens and toxins in the food supply has provided an opportunity for innovation. Three of 313 search results (1%) pertained to the *Removal of Toxins/Allergens*:

- The toxicological evaluation of crops (e.g. protein isolates and hydrolysates from canola);
- The inclusion of substances to prevent toxin formation (e.g. grape and clove extracts to prevent acrylamide formation in potato-based food products); and
- A green tea marinade to decrease the amount of carcinogens in cooked meat.

No further trend analysis was possible given the limited results in this category. These innovations were generally in the experimental stage of the commercialization pathway.

Overall, stakeholders agreed with this category as an emerging area of innovation. When polled, six out of eight webcast respondents indicated that removal of toxins or allergens from food products will be *somewhat important* or *very important* to their organizations over the next 10 years.

Regional participants mentioned residues from pea, hemp and canola as a regulatory concern. They suggested adding the technology to reduce ethyl carbamate in wine, along with removal of naturally occurring alkaloids, to the list.

One participant said that clients increasingly want toxin testing. Currently, European regulators require toxin testing; stakeholders questioned whether AAFC and CFIA would make toxin testing mandatory in Canada and indicated that, if so, they should consult with industry first. Other participants agreed that testing will have greater implications in future, particularly with off-shore ingredients. One participant commented that “monitoring” will have regulatory implications. A number of participants mentioned the need for quick, easy detection methods to meet Health Canada’s residue testing requirements.

Conclusions

The results from the environmental scan identified many emerging food products, technologies and processes that may contribute to human health and support innovative advances in the Canadian agri-food industry. Search results were classified into eight categories of innovation, which were further divided into sub-trends. The resulting domestic and international research themes were then discussed with select stakeholders to validate the findings and prioritize regulatory issues.

The representative agri-food stakeholders who attended either the webcast presentation or one of four regional sessions generally agreed with the findings of the environmental scan, and identified several additional innovations for consideration. In a number of cases, regional participants (who did not have access to the preliminary report prior to the session) identified missing examples which were in fact included in the report; this can be seen as further validation of the report's findings. The confirmation of importance to industry of the innovation categories identified by the environmental scan confirms that the findings are consistent with the industry landscape in Canada.

Moving forward, now that themes and priorities have been identified, there is an opportunity to further analyze specific areas and identify the regulatory implications of bringing specific initiatives to market.

Contact us to learn more about regulations for health claims, novel foods and ingredients.

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