

BOTANICALS & PLANT DERIVED EXTRACTS

Natalie Rouse

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Botanical markets, properties and sources

Botanicals have the ability to enhance health, create new flavours and add fragrance

BACKGROUND

Botanicals are defined by the food industry as fresh, dried, isolated compounds, essential oils, resins or collective chemical components derived from plants for their fragrance, flavour, functional benefits, therapeutic properties or uses as natural thickeners, emulsifiers and colourants. Botanicals are extracted from the plant by water, ethanol, CO₂ or organic solvent extraction. Some botanicals are classified via their desired properties, whilst others are classified as herbs, spices or piquant aromatic plant materials. There are approximately 250 botanicals commonly used in food and drink preparations. Botanicals are also used in cosmetics and perfumes due to their fragrance and skin enhancing compounds.

TRENDS

Within consumer purchasing trends taste reins the number one factor to gain repeat purchases and positive associations. Cost and convenience are also major driving factors, followed by health, the environment and sustainability. Botanicals fit all current trends. The use of botanicals is set to be a growing trend within 2019 and with the global market valued at \$54.6bn in 2013 and is projected to reach \$90.2 by 2020. Growing at a CAGR of 7.5% between 2017-2025, this includes nutraceutical supplements (Global Market Research 2017).

A collective of market research has flagged that botanical flavours will continue to be a major trend within the beverage, snacking, dining, confectionery and dairy markets, with consumers being eager to try new flavours and a notable change in taste, moving away from sweetness to more adult flavours (FMI 2019, Mintel 2019, Chu 2019, TFP 2019). Millennials and generation Z are accelerating the market share with a curiosity towards nostalgic tastes, reviving flavours and fragrances such as rose water, liquorish and aniseed. By combining traditional flavours with popular foods value can be added to food and beverage sectors, opening new concepts and driving product innovation.

Consumers are increasingly purchasing foods based on their associated health and wellbeing benefits that is echoed by consumer demand for natural remedies (Kantar 2019). Botanicals are being used for therapeutic and functional food ingredients and food supplements known as 'nutraceuticals' due to the compounds derived from the plants, herbs, seeds, algae's, fungi and fruits. All of which are gathering interest from health-conscious consumers propelling the food industry to develop and see high nutritive values in plant-derived products. Furthermore, those botanicals which can be certified organic can also command a higher premium (NutraIngredients 2019).

HEALTH ASSOCIATIONS

Functional foods are defined as possessing physiological or neurological benefits or containing very high nutritive values (EC 2019). The functional food trend is propelled via several factors, mainly due to consumer perception, marketing and social media influence. Many of the plant derivatives have functional associated benefits due to containing high nutritional values such as vitamins, minerals, polyphenols, antioxidants, high fibre. Functional foods gaining a large base research due to the increasing interest areas. The demand for 'functional foods' in the active and sports nutrition markets can be captured by the plant-based products. The demand for gut health enhancing foods has seen the rise in the demand for fermented products seeing (Deloitte, 2017).

Many botanicals have the associated label of being a 'Superfood'. To define such the Oxford English dictionary defines a superfood as a 'nutrient rich food, considered to be especially beneficial for health and well-being'. The EU has banned the use of the labelling Superfood without an accredited nutritional or health claim (EC 2019a). However, across the globe the term is used much more freely, attached to foods that are considered high in antioxidants, vitamins of minerals. The association as a food being a 'superfood' and labelling of foods as 'superfoods' does command a higher price. Associated words such as 'superfood', 'Natural' and the association that 'Natural is better' continues to drive the markets prosperity (Krystallis and Chrysosoidis, 2015).

Botanicals have attracted great attention within the food industry due to a large movement of consumers demanding natural ways to enhance their health – both physically and mentally. This is then further divided into those individuals who are interested in condition specific products that may provide a benefit or potential solution. There is a great shift and consumer interest to move away from pharmaceutical to nutraceutical remedies, with the perception that plant derived compounds are healthier and present fewer negative side-effects (Law 2019). Many of the compounds within botanicals have gained interest from anecdotal and ethnographic evidence along the scientific research that continues to contribute to the prevention of disease and alleviation of symptoms of various conditions. A recent review in The Food Science and Nutrition Journal has reopened research into how familiar herbs aid in disease prevention and management (Abdel-Salam (2018).). Currently multiple studies have been carried out administering botanical extracts to people with metabolic disorders, insulin resistance and obesity (Graf et al.2018, Izzo et al. 2016, Biesinger et al. 2016, Liu et al., 2017, Frontiers of Nutrition, 2019). The conclusion of such as presented positive results in all studies, this it is promising body of evidence which is gaining momentum driving researchers and consumers to seek botanical-based products. The utilisation of botanical properties, herbal remedies and nutraceuticals are important to gain expansion in the functional food markets, and meeting the health, active, sports and wellness markets, healthy aging, clinical and personalised nutrition markets demands.

Nutrient density is another interest within the use of botanicals. With an increasing number of nations, populated with people who are overfed whilst malnourished. Botanicals could serve as a powerful nutrient source to increase micronutrient intakes, particularly micro greens. Studies have shown micro greens contain significantly higher levels of magnesium, calcium, phosphorus, zinc, iodine and copper that adult crop varieties and hydroponically grown produce has enhanced nutrient contents (Aires 2018).

Reactive oxygen species (ROS), toxic oxygen compounds commonly called free radicals are by-products of human and animal metabolic processed. ROS are considered to be major contributors to many of the diseases associated with ageing including cardiovascular disease, some cancers, cataracts, impaired immune system and degenerative disease of the nervous system. ROS have the potential to damage lipids in membranes as well as proteins, DNA and other molecules critical to health, function and the body's innate defences (Lobo et al., 2019). Endogenous antioxidants in the human body require dietary support from antioxidants found in many plants. Plant derived antioxidant compounds are called polyphenols and can either inhibit ROS directly or can restore natural accident capacity (Kasote et al., 2015).

Current research has indicated that polypheonals have the ability to influence cell signalling pathways activated during inflammation the most recent polyphenols identified to deduce inflammation are from thymol and carvacrol found in herbs, spices and terpenes. These polypheonal have shown to inhibit the

oxidation of low-density lipoprotein (LDL). This can have a positive knock-on effect by reducing inflammation linked to LDL pro-inflammatory chemicals produced by the immune system (de Oliveira et al. 2018).

Flavonoids are found in low concentrations in herbs, spices and polyphenols, but they too are powerful antioxidants. Anthocyanins are another powerful group of antioxidants that are in a variety of foods with a red colourant; red cabbage, red berries, plums and beetroot with powerful anti-inflammatory agents. Carotenoids are pigments with antioxidant properties that have been linked to the protection of certain cancers, infections and noncommunicable disease. zeaxanthin is one of the most common carotenoids and gives many spices such as saffron, corn and paprika their yellow colourants.

RECENT INTEREST

Cranberries have been accredited the highest antioxidant fruit mostly known for their anti-adhesion activity protecting the body from bacteria and pathogens commonly used for a urinary tract infection. Anti-adhesion activity is primarily due to the compound proanthocyanidins (PAC's) and its unique structure. In 2004 cranberries gained a health accredited claim (Selvamuthukumaran et al.2018).

Pomegranate has also gained traction with its juice aiding the reduction of atherosclerotic plaques in wide scale studies. Additional studies have also shown pomegranates protective effects on prostate cancer (Lutz 2019). Such studies have gained great interest into pomegranates health claims.

Acai berry has become very popular within recent years both as a supplement and as a dried berry. Originating from Brazil the berry is very high anthocyanins, omega-3 fatty acids, and polyphenols. Research on such berry has backed the antioxidant properties due to its defence on free radicals being much higher compared to European fruits and juices (Proestos et al. 2018).

Goji berries have exploded onto the health and well-being scene. The berries provide both nutritious and functional properties claiming to enhance immune system, protect the liver, improve circulation and aid eye health . Goji berries are a rich source of zeaxanthin (MA et al.; 2019). Originating from China the fruit is a species related to the nightshade family. Nightshades are commonly grown in the UK such as; potato, tomato, aubergines and chilli peppers.

Curcumin is the active compound found within turmeric which has shown to be a powerful antioxidant and a powerful anti-inflammatory through reducing prostaglandins and other pro-inflammatory proteins while increasing the production of endogenous antioxidants (Cheng et al. 2019).

Quercetin from the herb, Dill has also presented anti-inflammatory properties in laboratory studies (Wasli 2018).

SAFETY

Botanicals and plant extracts are widely available in supermarkets, health food shops and online. Ginkgo, garlic, St. John's wort and ginseng are labelled as natural foods and are accompanied by a wealth of health associations, selling in great volumes. Whilst many of these have been used for centuries and considered safe some botanicals present safety concerns due to possible chemical and microbiological contaminants and concerns over safe intake of bioactive compounds.

The EU does not have a central authorisation procedure for the use of botanicals and derived preparations in food but sets out general requirements in Regulation (EC) No 178/2002, which provides general principles

and requirements for food law in the EU. There are also some grey areas such as traditional botanicals that are used for medicinal products and in food supplements. For medicinal purposes the European Medicines Agency (EMA) is responsible for assessing both the safety and efficacy of herbal preparations when used as medicines. It is not the role of The European Food Safety Authority (EFSA) or EMA to determine if a botanical is a medicine or food source.

The Food Standards Agency (FSA) has committed to provide accreditation of the safety of botanical using scientific-based evidence and sharing such to any organisation that requiring it. The FSA has provided criteria that should be taken into consideration when establishing the safe use of botanicals or plant derived preparations and in 2009 the EFSA published a toolkit to aid the assessment of botanicals usage and safety for its use within food, drink and supplements. A regularly updated 'Compendium of Botanicals' provides a list of botanicals that have established safe limits and recommended usage (EFSA 2019).

Table 1; Commonly used botanicals in food and supplement industry.

Botanical	Latin name	Active substrates	Sold for;	Raw form	Extraction
Acacia gum	<i>Acacia sp.</i>	90% fibre content	Digestion, weight management, sports performance	Dried leaves and bark	Water extraction and freeze drying
Acai	<i>Euterpe oleracea Mart.</i>	high anthocyanins, omega-3 fatty acids, and polyphenols.	Antioxidants. Anti-aging, immunity	Berry	Water extraction and freeze drying and ethanol extraction
Acerola extract	<i>Malpighia glabra L.</i>	Up to 25% Vitamin C. The acerola berry is particularly rich in vitamin C. There is 40 to 100 times more vitamin C in a glass of acerola juice than in a glass of orange juice. It is considered in conventional and alternative health practices as a powerful antioxidant.	Energy, Immune support, High in vitamin C	Fruit puree	Water extraction and freeze drying
Apricot	<i>Prunus armeniaca L.</i>	Rich in antioxidants	Digestion Eye health	Fruit	Water extraction and freeze drying and juicing

Artichoke extract	<i>Cynara scolymus</i>	5% Crynarin. Artichoke leaves have the highest anti-oxidant content compared to other vegetables. Natural diuretic, shown to reduce LDL cholesterol by inhibiting HMG-CoA reductase. The leaves are also known their medicinal properties for liver protection. They also have other physiological properties. Greeks and Romans have imported this plant to use it to facilitate digestion and to reduce hepatic and renal troubles due to Crynarins enhanced bile flow abilities.	Digestion	Dried leaves	Water extraction and freeze drying
Baobab	<i>Adanonta digitate L.</i>	High vitamin C and controls blood sugar	Antioxidants. Anti-aging and immunity	Fruit	Water extraction and freeze drying
Beetroot	<i>Beta vulgaris L.</i>	0.5% betalainins	Joint health,	Root vegetable	Fresh or Water extraction and freeze drying
Black current	<i>Vibes nignium L.</i>	15% polyphenols	Joint health, digestion, immunity, male and female wellbeing, weight management, super food	Leaf	Water extraction and freeze drying
Black pepper	<i>Piper nignium</i>	20% inulin	Digestion	Pepper corns	Soft ethanol extraction &

					Spray-drying
Blueberry	<i>Vaccinium myrtillus L.</i>		Male and female health, superfood	Fruit	Water extraction and freeze drying Or juicing
Cinnamon	<i>Cinnamomum zeylanicum blurne</i>	20% PAC's, 25% polyphenols	Antioxidants, Anti-aging, immunity, digestion, male and female health, immunity	Inner bark	Soft ethanol extraction & Spray-drying
Cherry stem	<i>Prunus caracus L.</i>	High in antioxidants	Male and female health, weight management	Stem and fruit	Water extraction and freeze drying
Chlorella	<i>Chlorella vulgaris Beijerinck</i>	50% protein	Male and female health	Algae	Water extraction and freeze drying and ethanol extraction
Cranberry extract	<i>Vaccinium macrocarpon</i>	Up to 50% A-type PAC's. Consumed to acidify urines that creates an unfavourable middle for bacteria development. Cranberry's beneficial effects comes from its capacity to prevent bacteria adhesion to urethra and bladder wall thus protecting from urinary tract infections (UTIs)	UTI's Oral care Super fruit	Fruit	Water extraction & Resins & Spray-drying
Devils claw extract	<i>Harpagophytum procumbens</i>	Up to 20% Harpogosides. Primarily used for its joint health properties.	Joint health	Root	Water extraction and freeze drying

		Many studies verify the effectiveness of devil's claw against arthritis pain.			
Fengreek	<i>Trigonella foenum-gracecum L.</i>	50% saponins	Cardio vascular health, digestive		Soft ethanol extraction & Spray-drying
Garcinia cambogia	<i>Garcinia Cambogia</i>	Up to 60% hydroxycitric acid. 60% HCA. Rich in hydroxycitric acid (HCA), an active compound which plays a major role in the regulation of body weight and appetite. HCA is an inhibitor of acetyl-coenzyme A and acts on the metabolism of sugars and fats. Garcinia cambogia is an excellent food supplement for weight management.	Fat loss; Increases BMR and suppresses appetite	Fruit	Water extraction & Crystallization
Ginseng panax	<i>Panax ginseng CA mayer</i>	5% ginsenosides	Conative health	Root	Soft ethanol extraction & Spray-drying
Grape seed extract	<i>Vitis Vinifera</i>	95% polyphenols Grape seed extracts are derivatives from whole grape seeds that have a great concentration of vitamin E, flavonoids, linoleic acid and phenolic procyanidins (OPC) which are known for their powerful antioxidant properties.	Anti-aging	Grape seeds	Water extraction & Resins & Spray-drying

		Recent studies showed that white grape seed extracts could be involved in improving antioxidant status by reducing free radicals production and limiting cardiovascular risk by increasing adiponectin expression.			
Green coffee bean extract	<i>Coffea canephora (robusta)</i>	15% Chlorogenic acid intellectual and physical activity stimulation and increasing of energetic consumption. Chlorogenic acid is involved in carbohydrates and fats metabolism regulation. Green coffee is an excellent food supplement for weight management.	Fat burner; Increases BMR and stimulates CNS	Dry beans	Water extraction & Spray-drying
Green tea extract	<i>Camellia Sinensis</i>	80% Polyphenols Green tea is used not only for its astringent, digestive and tonic properties but also for the antioxidant value of its polyphenols.	Anti-aging Antioxidant	Leaves	Water extraction & Spray-drying
Guarana Extract	<i>Paullinia cupana</i>	Up to 22% Natural caffeine Shown to reduce hypoglycemia and the feeling of hunger, making guarana very	Energy	Seeds	Water extraction & Spray-drying

		interesting for supporting endurance and weight loss programs			
Hops extract	<i>Humulus lupulus</i> L.	Hop is traditionally used for relaxation, sedation, and in case of insomnia and has also been used to reduce anxiety	Anti-stress Sleeping aid	Cones (female flowers)	Soft ethanol extraction & Spray-drying
Lemon balm	<i>Melissa officinalis</i>	The leaves have a gentle lemon scent, related to mint. Its flavour comes from the citronellal, citronellol, citral, and geraniol terpenes. Lemon Balm is traditionally used as a herbal tea, or in an extract form. It is supposed to have antibacterial, antiviral, sedative and calming Properties	Anti- stress	Leaves	Water extraction & Spray-drying
Lemon juice	<i>Citrus limon</i> (L) <i>Burm.f.</i>	High in antioxidants.	Weight management	Juice	Juicing
Marine Magnesium	<i>Spray dried desalted water</i>	Helps cope with magnesium deficiencies. Its specific geographical origin allows a unique mineral profile. Gentle and solvent free process allows reduction of sodium and chloride content.	Supports 10 Health Claims in Europe, including: tiredness and fatigue, muscle function, normal bone	Desalted sea water	Crystallization & Spray-drying
Matcha	<i>Camella sinensis</i> (L.) <i>Gaertn.</i>	Powder contains <3.5% caffeine	Antioxidant, weight management	Leaves	Water extraction & Spray-drying

Milk thistle	<i>Silyburn m arlanum L.</i>	10% polyphenols	Digestion	Plant stem and thistle flower	Water extraction & Spray-drying
Nettle leaf extract	<i>Urtica dioica L.</i>	Their extract contains active compounds which can help to reduce TNF- α and other inflammatory cytokines and could be recommended for joint health.	Anti-inflammatory Diuretic	Leaves	Water extraction & Spray-drying
Nucleotides from yeast extract	<i>Saccharides cerevisiae</i>	80% nucleotides	Digestion	Yeast extract	Extracting the acid with alamine/ freon and precipitation method
Olive fruit	<i>Olea europaea L.</i>	5% Hydroxytyrosol	Cardio vascular health, digestion, joint support	Leaves, Fruit	Water extraction & Spray-drying
Papaya	<i>Larcia papaya L.</i>	High vitamin C and lycopene, 25% polyphenols	Digestion, Antioxidant	Plant stem, Fruit, seeds and peel	Water extraction & Spray-drying
Passion flower extract	<i>Passiflora incarnata L.</i>	The sedative properties of Passion Flower come from its alkaloids content, including monoamine-oxidase inhibitor (MAO).	Sleeping disorders Anti-stress	Flower	Water extraction & Spray-drying
Pomegranate Extract	<i>Punica granatum</i>	25% polyphenols 8% ellagitannins This antioxidant power is due to its ellagic acid content: a polyphenolic compound naturally found in pomegranate	Gastro-intestinal health, Antioxidant	Fruit skin, seeds	Water extraction & Spray-drying

Rice protein	<i>Oryza sativa</i>	High protein content (80%) and is rich in all essential and semi-essential amino acids including 15% of Branched Chain Amino Acids (BCAAs) with a ratio 2/1/1 in Leucine, Isoleucine and Valine.	Hypoallergenic source of Branched Chain Amino Acids for Baby Food, Sport Nutrition, Sarcopenia	Rice grain	Enzymatic hydrolysis & Spray-drying
Sage	<i>Salvia officinalis L.</i>	20% polyphenols	Digestion, Antioxidants. Anti-aging	Leaves	Ethanol extraction & Spray-drying
Spirulina	<i>Spirulina platenis geitler</i>	60% protein	Joint health, sports performance, digestion, immunity	Algae	Water extraction and freeze drying and ethanol extraction
Turmeric extract	<i>Curcuma longa</i>	95% Curcuminoids Turmeric (or Curcumin) is a plant coming from Asia, which is particularly cultivated in India and China. In India, curcumin is traditionally used as a spicy ingredient for cooking. The main colouring agents belong to the curcuminoids family. Major compounds identified by chromatography are: curcumin, dimethoxy-curcumin and bis dimethoxy-curcumin.	Anti-inflammatory Digestion (liver disorders)	Root (Rhizome)	Ethyl acetate extraction & Crystallization

Valerian	<i>Valeriana officinalis L.</i>	0.8% valeric acids	Digestion, reduced anxiety, aids sleep	Root	Water extraction and freeze drying
Yaba Mate	<i>Ilex paraguayensis</i> <i>A. St. Hil.</i>	8% caffeine	Energy, weight management	Leaves	Water extraction and freeze drying

*data from a collective of journals and the EFSA Compendium of Botanicals.

CANNABIS

Cannabis has gained huge traction and interest from a wide range of industry and consumers; as food ingredient, drink and medicinal supplement. Cannabis is believed to be one of the oldest domestic crops dating back 6000 years. The taller and more sturdy crops were bred with other crops with similar characteristics, leading to the strain of cannabis known as Hemp and used to make a variety of foods, oils and textiles, rope and fabrics. The other plants were identified as having psychoactive properties and were selectively bred for recreational, medicinal and religious purposes, leading to the unique strains of cannabis commonly known as Marijuana, weed (Chen et al. 2018).

All cannabis strains contain cannabinoids, with up to 60 different cannabinoids discovered to date. THC is the compound associated with the psychoactive properties and getting 'high'. Psychoactive cannabis strain contains up to 30% THC whereas, hemp strains contains very little accounting <0.2%. For a cannabinoid product to be legal it must contain <0.2% THC and therefore hemp is the obvious choice (Bullard 2018). Psychoactive cannabis is illegal in the UK and many other countries, but the hemp strain of cannabis is legal along with extracted CBD oil in supplements, infusions, extracts, ingredients and essential oils.

Hemp is also much higher in CBD than cannabis. CBD is the most abundant cannabinoid, naturally present within industrial hemp plants and its extracts. CBD is non-psychoactive, non-intoxicating and not known to be addictive, furthermore, CBD is considered to be well tolerated in humans (Nahla 2019). Extracting CBD from hemp uses the method of cold pressing, ethanol extraction or CO2 extraction. Once extracted the extract can be left raw or decarboxylated and added to consumer products without further need for processing or it can be distilled to remove elements such as chlorophyll.

CBD's anti-oxidant and anti-inflammatory properties have been widely acknowledged and subjected to multiple studies, yet more is required to accredit CBDs therapeutic effect (Gallily 2018). Many CBD based products are available to buy within stores and online. Currently CBD is classified as a 'novel food'. The EFSA states that a novel food is classed as a 'food that had not been consumed to a significant degree by humans in the EU before 15th May 1997'. As the industry continues to grow new classifications will likely be enforced (EFSA 2019). Additionally The World Health Organisation (WHO) released a statement that CBD poses 'not health problems' and is not harmful' (WHO 2019), and the World Anti-Doping Agency (WADA) stated that 'Cannabidiol is no longer prohibited' -THC is (WADA 2019).

The CBD market is driven by the \$49bn herbal supplement market, the growing anxiety economy and rise of legal cannabis market place. The use of CBD compounds can be added by multiple industries; beverages, human health, pet health, food supplements and food ingredients claiming a wide array of health attributes. There are still large gaps in the research knowledge and health associations of CBD and due to its growth,

the regulation has been inconstant, but this has not prevented consumer interest or held back consumers from purchasing it. The versatility and associated benefits of CBD saw the market worth \$535m in 2018 and forecast to be a \$2bn industry by 2022 (Forbes 2019).

Within the UK, specialist clinicians are able to prescribe cannabis oil with a high cannabinoid content (of both CBD and THC) for individuals with exceptional circumstances to treat conditions such as, autoimmune diseases, epilepsy, pain relief and relieving nausea or vomiting experienced during chemotherapy treatment (DofH 2019). Medicinal cannabis must be sources from registered growers. The UK produced 95 tonnes of medicinal cannabis in 2016-2017 for scientific use, approximately 45% of the total world medicinal cannabis growth (Campbell 2018). The UK governments have been clear that the authorisation of medicinal cannabis will not pave the way to legalising cannabis for recreational use.

Table 2; List of the main identified cannabinoids and their associated health attributes.

Compound	Properties
CBG	Aids sleep Inhibits cancer cell growth Promotes bone growth Slows bacteria growth
CBGA	Reduces inflammation Relives pain Slows bacteria growth
CBC	Inhibits cancer cell growth Promotes bone growth Reduces inflammation Relieves pain
CBCA	Reduces pain Reduces inflammation Treats fungal infections
Δ-9-THCA	Aids sleep Inhibits cancel cell growth Reduces muscle spasms
Δ-9-THC	Reduces vomiting and nausea Relieves pain Stimulates appetite Supress muscle spasm
Δ-8-THC	Relives pain
THCV	Reduces convulsions and seizures Promotes bone growth
CBD	Antibacterial Inhibits cancer cell growth Neurological protection Promote bone growth Reduces convulsions and seizures Reduces blood sugar levels

	<p>Reduces function in the immune system</p> <p>Reduces inflammation</p> <p>Reduced arterial plaques</p> <p>Reduces vomiting and nausea</p> <p>Relieve pain</p> <p>Relieves anxiety</p> <p>Suppress muscle spasm</p> <p>Treat psoriasis</p> <p>Vasodilator</p>
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*Cannabinoids list compiled from (Alexander & Molina-Holgado, 2019, Brenneisen 2018)

CEA AND BOTANICALS

Growing botanicals, including cannabis via CEA will ensure and maintain year-round supply. Currently the limited supply of raw materials and extracts had challenged the growth of the botanical market, but CEA can assist this growth. Many herbs, fungi, cannabis, fruit, vegetables, edible flowers, stevia (natural sweetener) and plants can and are already grown via CEA, hydro and aeroponics.

Currently natural variation has presented inconsistency of compounds, leading to questions surrounding the health and nutritional claims. Through utilising CEA's control methods, such as nutrient delivery, water sensors, specialised LED lighting and growing mediums a consistency in the levels of nutrients, compounds, polyphenols, antioxidants and their profiles can be achieved (Smith 2018). This consistency could aid research and compound analysis to assist the accreditation of nutritional, health and functional food claims. Additionally, CEA does not require pesticides, reducing chemical contamination or negatively effecting soil quality. CEA also uses less water compared to field crop growing and therefore eliminating eutrophication (Al-Kodmany, 2018), fitting within environmental and sustainability policies.

SUMMARY

Botanicals sit well within consumer demands for fresh, identifiable ingredients to enhance health and wellness, support healthy aging and conscious moves towards following a healthier lifestyle. There is great potential in the health and nutraceutical industries to utilise botanical extracts.

More research is required to fully explore the extent of the properties bound within botanicals, fruits, vegetables, herbs, spices fungi etc to understand the interaction of the compounds and how they work. This can give credit to health claims and aid to explain why some of the single isolated antioxidants have failed to fully demonstrate the health benefits once removed from the whole plant. Research can investigate which compounds and extracts work in synergy to promote health and well-being.

Botanicals have demonstrated positive results in a range of clinical trials showing great potential within medicinal use.

Botanicals present great potential for food and beverage innovation. By exploring the vast range of unique fragrances and flavours many new concepts and consumer experiences can be created.

Botanicals are well placed in the current and emerging markets including; health, plant-based, nutraceuticals, beverage, food supplement and functional food markets.

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