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The Preventive Approach of Biocompounactives (1): A Review in Recent Advances in Common Vegetables and Legumes

Abdelkarim Guaâdaoui[1, *], Fatma Bouhtit[2], Abdellah Hamal[1]

[1]Department of Biology, Laboratory of Genetics & Biotechnology (LGB), Faculty of Science - Oujda (FSO), University Mohammed Premier (UMP) Oujda, Morocco
[2]Department biological analysis, Laboratory for Analysis and Quality Control (LACQ), University Mohammed Premier (UMP) Oujda Morocco

Email address:
abdelkarim119@gmail.com (A. Guaâdaoui)

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Abstract: All scientific studies confirm that a varied and balanced diet is factor of protection against cancer, cardiovascular disease (CVD), osteoporosis, diabetes, obesity and high cholesterol. The philosophy that food can be health promoting beyond its nutritional value is gaining acceptance within the public arena and among the scientific community as mounting research links diet/food components to disease prevention and treatment. Biocompounactives contain chemicals that are found in small quantities in plants and certain foods (such as fruits, vegetables, nuts, oils and whole grains), they have actions in the body that can promote good health. In this work, we focus on studies that have been conducted on biocompounactives of common vegetables and legumes, and opportunities that present bioactivity of these phytochemicals to prevent many chronic diseases. As well, emphasis is placed on some challenges that face the good investissment of biocompounactives.

Keywords: Biocompounactives, Bioactive Compound, Phytochemicals, Functional Foods, Healthy Diet, Nutraceuticals

1. Introduction

Biocompounactives are compounds which have the capability and the ability to interact with one or more component(s) of the living tissue by presenting a wide range of probable effects. These compounds are experiencing a growing interest in wide range of applications: geo-medicine, plant science, modern pharmacology, agrochemicals, cosmetics, food industry, nano-bio-science... etc. This is a very promising area in full development, which has resulted in research works more and more numerous, designed to diversify the resources of bioactive compounds and improve their salvage pathways or synthesis [1, 2].

The philosophy that food can be health promoting beyond its nutritional value is gaining acceptance within the public arena and among the scientific community as mounting research links diet/food components to disease prevention and treatment [3, 4]. Noting that prevention is a more effective strategy than is treatment of chronic diseases [5].

Interest in food composition has expanded beyond the nutrients to include bioactive compounds consumed in the traditional foods, which may help to prevent many chronic diseases that can coexist with malnutrition and undernutrition [6].

Recent trends in the functional food market suggest that products with multiple health benefits become more and more popular [7] and dietary bioactive compounds have become another quality indication [8].

2. Food Biocompounactives Opportunities

The importance attached to benefits of food on health has never been so high before [3]. Indeed, over the past two decades, there has been a growing interest in the potential benefits of natural compounds on human health [9], and if we except the genetic, ecological, physiological and botanical studies on food; research on the bioactive potential has experienced a veritable boom during the first decade of the twenty-first century, and took an accelerated rates over the beginning of the second decade, in a way that the research carried out during the past five years (2010-2014) on the majority of foods are equal or superior to the work done during all the previous decade (2000-2009).

Biocompounactives are members of a large class of organic molecules that are widely distributed in the plant kingdom and, as such, are an integral part of the daily diet of humans [10].

Until 2013, it was estimated that more than 8000 phytochemicals have been identified in foods [11]. All these bioactive food components are mostly found in whole grains, fruits and vegetables [12, 13], but a large percentage still remain unknown and need to be identified before we can fully understand the health benefits of phytochemicals in whole foods [12].

The phytochemicals may be classified into carotenoids, phenolic compounds, alkaloids, nitrogen compounds and organosulfur compounds. But the most studied of these biocompounactives are phenolics and carotenoids [14].

Recent investigations show that food biomolecules that contribute to human health can be found particularly in glycosylated, esterified, thiolated or hydroxy forms. These bioactive compounds display their health benefits in metabolic activity associated with several diseases [13].

Liu RH (2003) proposes that cumulative and synergistic effects of phytochemicals in fruits and vegetables are responsible for their powerful antioxidant and anticancer activities, and the benefit of a diet rich in fruits and vegetables is attributed to the complex mixture of phytochemicals found in whole foods [5].

So the important role that biocompounactives can have in health is related to the intake of these compounds, which, in turn, strongly linked to the high consumption of fruits, vegetables and unrefined grains [15]. Indeed, several studies have shown that a high intake of fruits and vegetables reduces the risk of cardiovascular disease, certain cancers, and other chronic diseases [14, 16-19].

The concept of a healthy diet is considered an aspect of good and healthy practices. The observations in social behavior and archaeological discoveries lead researchers to notice that the longevity and healthy life, away from the high incidence of myocardial infarction and cancer, are caused by good habits of feeding [20].

Thus, several studies have demonstrated a significant reduction in the risk of chronic diseases, and beneficial health effects of bioactive compounds of certain eating habits and diets, such as the traditional Japanese diet that contains a high content of soy products and vegetables [21-23], the Mediterranean diet [15, 24-26], which contains a high content of olive oil, fruits and vegetables, and wholegrain bread; and the regime of "prudence" diet [27, 28] which is characterized by a high consumption of fruits and vegetables, fish and poultry, whole grains (barley, oats, rice ...) and legumes.

Early in 2013, for example, a scientific study conducted on 7500 people who were observed over a period of five years has revealed that those who have a Mediterranean diet reduced the risk of heart disease by 30% compared to people who follow a diet low in fat alone [29]. Several studies have reached similar conclusions [30-36], and mortality statistics from the World Health Organization (WHO) have provided evidence that diet in Mediterranean countries had health implications in respective populations and, in particular, their coronary health [37].

Table 1 constitutes a concise review of common vegetables and legumes, their bioactive constituents and bioactivities studied that present enormous opportunities for human health.

Table 1. *Bioactivity of dietary biocompounactives (vegetables and legumes case).*

Vegetables & Legumes	Bioactivities studied	Biocompounactives	References
Artichoke *Cynara cardunculus* (Asteraceae)	Reduce the risk of colon cancer / Prevent constipation Control of type 2 diabetes Treat high cholesterol Effectiveness of the intestinal flora	Phenolic compounds: Caffeoylquinic acid Soluble and insoluble fiber (inulin)	[38-48]
Bean *Phaseolus vulgaris* (Fabaceae)	Lower risk oesophageal and stomach cancer Modulate cardiovascular risk factors and obesity Decreased bone degradation Anti-tumor, antioxidant & phyto-estrogenic activities	Flavonoids (quercetin) Saponins Propionic & Oleanolic acids Fiber	[49-60]
Beet *Beta vulgaris* (Chenopodiaceae)	Anti-tumor / Anti-inflammatory Antidiabetic & Liver protection Prevent dementia and cognitive decline	Betalain Flavonoids Lutein & Zeaxanthin Fiber	[2, 61-69]
Cabbage *Brassica oleracea* Cauliflower *Brassica oleracea var. botrytis.* (Brassicaceae)	Decrease of overall cancer risk Self-destruction of cancer cells Lower risk of lung cancer and pancreatic cancer Slow cognitive decline (in women) Control diabetes Immunomodulatory	Flavonoids (cyaniding) Carotenoids Tocopherols Glucosinolate (Sinigrin & Glucobrassicin) Allyl isothiocyanate (AITC) Fiber	[70-85]
Carrot *Daucus carota* (Apiaceae)	Prevent certain cancers (lung, breast, blood) Prevent atherosclerotic process (CVD) Prevent some age-related diseases such as cataracts Antidiabetic potential / Lower cholesterol and triglycerides	Carotenoids: beta-carotene, lutein & zeaxanthin Crotonic acid Polyacetylene Soluble fiber	[86-93]
Chickpea	Beneficial effects on the bacterial colonic flora	Flavonoids	[94-105]

Vegetables & Legumes	**Bioactivities studied**	**Biocompounactives**	**References**
Cicer arietinum (Fabaceae)	Cholesterol lowering (CVD) Antioxidant power Diabetes Control	Saponins Carotenoids (β-carotene) Fiber	
Cucumber Gherkin *Cucumis sativus* (Cucurbitaceae)	Antioxidant activities Antidiabetic potential Activities against the signs of aging Prevent constipation Soothing effect against irritation of the skin and reduces swelling Relax and relieve the pain of sunburn Protection against oxidative stress	Cucurbitacins, Vitexin, Orientin, Isoscoparin & Apigenin Cucumegastigmanes I and II Cucumerin A and B	[106-113]
Eggplant *Solanum melongena L.* (Solanaceae)	Decrease (*in vitro*) of: • Abnormal proliferation of blood vessels (antiangiogenic properties) • Concentration of blood lipids Anti-aging p properties	Chlorogenic acids Nasunin (polyphenol) Anthocyanins	[114-121]
Fava bean *Vicia faba* (Fabaceae)	Improve the treatment of Parkinson's disease cholesterol-lowering effect Maintain proper bowel function Antioxidant activities	Levodopa (L-DOPA) Rutin, Proanthocyanidin, Vicin & Convicine Gallic acid Fiber	[122-133]
Garlic *Allium sativum* (Alliaceae)	Prevention of certain cancers Cardioprotective effect / Cardiovascular Hypertension & Antimicrobial Activity Enhance the immune system	Organosulfur compounds (Allicin) Flavonoids Tocopherols Saponins	[5, 134-142]
Leek *Allium porrum* (Alliaceae)	Strong antioxidant power Anticancer & antifungals properties	Sulfur compounds Flavonoids (kaempferol) Carotenoids: (β-carotene) Saponins & Sapogenins	[143-149]
Lentil *Lens culinaris* (Fabaceae)	Inhibit the growth of cancer cells *in vitro* Treatment & prophylaxis of retroviral infections (HIV) Hypotensive & Hypoglycemic effects Antioxidant activities Prevent constipation	Flavonoids: procyanidins, catechins, anthocyanins & delphinidin Saponin Lectin (LCA) Insoluble fiber	[150-161]
Lettuce *Lactuca sp.* (Asteraceae)	Reduce lung cancer risk Neuro-protective effects *in vitro* cholesterol-lowering power Antibacterial, antiviral & antioxidant activities	Flavonoids: quercetin & anthocyanins Carotenoids: β-carotene, lutein & xanthines Fiber Caffeic & Coumaric acid	[162-167]
Onion *Allium cepa L.* Green onion *Allium spp.* (Alliaceae)	Reduce the risk of colon, larynx & ovaries cancer Lower risk of the digestive tract and brain cancer Decrease platelet aggregation *in vitro* Reduce blood triglyceride levels Protect kidney function (in rabbits) Prevent and treat heart and acute vascular complications Antimicrobial & Antioxidant activities	Flavonoids: anthocyanins & flavonols (quercetin) Saponins Sulfur compounds Vitamins B6 & C	[168-181]
Peas *Pisum sativum* (Fabaceae)	Antiproliferative activity (colon cancer) Cholesterol lowering Lower risk of macular degeneration and cataracts Protect the macula and retina of the eye from oxidative stress Antioxidant activity	Flavonoids: quercetin, luteolin & apigenin Carotenoids: Lutein & Zeaxanthin Fiber	[64, 155, 182-189]
Potato *Solanum tuberosum* L. (Solanaceae)	Induce apoptosis / Reduce proliferation of human prostate cancer cells / Antimutagenic properties Reduce the risk of colon cancer Inhibit breast cancer (in rats) Neuroprotective activity in vitro Reduce inflammation & oxidative stress (in men) / Skin care Lower cholesterol & blood triglycerides	Flavonoids: quercetin, kaempferol & catechins Chlorogenic & Caffeic acids Carotenoids: Lutein & Zeaxanthin Glycoalkaloids Fiber Lectin (STL)	[190-208]
Pumpkin / Squash / Zucchini / Pattypan *Cucurbita pepo* Potiron *Cucurbita maxima* (Cucurbitaceae)	Anti-carcinogenic / Anti-inflammatory Protective against hyperglycemia Lower risk of macular degeneration and cataracts Enhance certain functions of the immune system	Flavonoids Carotenoids: βand α-carotene, lutein, zeaxanthin, β-cryptoxanthin Alkaloids Tocopherols / Rutin Cucurbitacins	[209-221]
Radishes *Raphanus sativus* (Brassicaceae)	Reduce the tumors formation and the growth of cancer cells *in vitro* Antimutagenic properties *in vitro* Prevention of colon cancer	Flavonoids: Kaempferol & Anthocyanins (pelargodinines) Glucosinolate / isothiocyanate	[222-242]

Vegetables & Legumes	Bioactivities studied	Biocompounactives	References
	Slow cognitive decline (in older women) Accentuate intestinal motility in animals (stimulate the digestive system and promote intestinal elimination) Lower cholesterol & triglycerides	Methyl-isogermabullone	
Turnip *Brassica rapa* (Brassicaceae)	Limit the development of cancer cells and some metastases Antioxidant protection in tissues Lower risk of macular degeneration and cataracts	Glucosinolates / Phenylethyl isothiocyanate (PEITC) Isorhamnetin Carotenoids: Lutein & Zeaxanthin Hydroxycinnamic acids / Vitamin C Fiber	[243-254]

3. Challenges of the Preventive Approach of Biocompounactives

3.1. How to Provide Science to the Public

The diet reflects the preferences and eating habits, and diversity of human experiences, which have evolved in many models over time [255], knowing that indigenous peoples have never separate food from medicine, on how our modern world is now [256]. Unfortunately, social changes seem to have always contributed to the radical reversal dietary habits [257, 258], and the real challenge on this side is how to adopt such a healthy diet in a world more and more westernized [259], and save the transmission of knowledge in terms of traditional gestures, celebrations, rituals and techniques, which continue to lose today [256, 257].

On the other side, and despite all the efforts of many government [260-264] and international institutions [265], the available nutrition information can seem quite complex, not well understood by the majority of consumers, and of limited use when preparing family menus without a good knowledge. It is therefore necessary to provide advice in a way that consumers can understand [262].

In this framework, Herber D. (2002) proposes a method to translate the science of dietary phytochemicals, in dietary recommendations for the public, with the selection of foods based on colors that encode the content of phytochemicals [266, 267]. The author has categorized foods according to their colors into seven groups (Table 2) which consumers should ingest a portion of each of the seven groups every day, and requested the concerned institutions to introduce 5-9 portions among the recommendations, where the total amount will be between 400 and 600g/day of fruits and vegetables. This quantity is associated with a reduced incidence of many common cancers. According to international studies, for some cancers of the aerodigestive tract, the risk is reduced by 50% [268, 269].

The grouping of plant foods by color provides simplification to encourage increased intake of fruits and vegetables, but it is also important as a method to help consumers to make wise food choices and promote health. For example, red foods contain lycopene, pigment of tomato, which is localized in the prostate gland and may be involved in maintaining the health of the prostate, which was also linked to a decrease in the risk of cardiovascular disease. Green foods, including broccoli, Brussels sprouts and cauliflower, contain glucosinolates that have been associated with a decreased risk of cancer. Garlic and other white-green foods in the onion family contain allyl sulfides that can inhibit the growth of cancer cells. Other bioactive substances in green tea and soy also have health benefits… etc. [267, 268].

Table 2. *The color-code of food groups [268] (modified) [301]*.*

Color	Phytochemicals	Examples
Red	Lycopene	Tomato
Red / Purple	Anthocyanins & Polyphenols	Grapes, berries
Orange	α- and β-carotene	Carrot, pumpkin
Orange/Yellow	β-cryptoxanthin & Flavonoids	Orange, melon
Yellow/Green	Lutein & Zeaxanthin	Avocado, spinach
Green	Glucosinolates & Indoles	Broccoli, cabbage
White/Green	Allyl sulfides	Garlic, onions
White*	Carotenoids & Polyphenols	Potatoes, turnips

In 2013, Barnes S. et *al.* have criticized the method based on color, asking if we can 'see' what is good for us in nutrition? It is true that phytochemicals are the (different) food colors. But color is not necessarily an indication of what or how many phytochemicals, beneficial or toxic, are present in what we eat. The color can be an indicator of some phytochemicals, but not others. Although, the food colors can mislead the consumer about the actual content of nutrients and phytochemicals, as many of these compounds are colorless in one side or, on the other side, human eyes cannot directly judge the content of these compounds, because human vision is limited to a small window of the electromagnetic spectrum (390-765nm). Besides, several phytochemicals can be transformed or lost during the process undergone by food, such as cooking [270]. Thus, the authors highlight that dietary advice based on color is a wrong approach for overall content of bioactive compounds.

This debate leads us to put forward the possibility of the integration of biocompounactives directly into the dietary recommendations. But what is needed to develop a framework that can be used to make health recommendations for bioactive food components? The answer to this question has built the axis of discussions in a symposium held in April 2013 by the American Society for Nutrition (ASN, Boston).

Indeed, although a framework exists to establish recommendations for essential nutrients; such a framework does not exist for non-essential bioactive constituents in food. Despite a myriad of factors that make the measure of their contributions and the study of their effects difficult, a new framework to determine the recommended intakes for bioactive compounds is justified, since without dietary recommendations for biocompounactives, and from a public health point of view, there will be a perpetuation of the status quo of current diets containing lower food intake, and consequently of bioactive compounds that can support optimal health. While the transmission of accurate and reliable information about the health benefits of a large number of bioactive food components would improve public understanding of the importance of the safe use of these compounds for the promotion of health [271].

The development of an alternative path for formulating dietary recommendations for bioactive components encounter, in its turn, several challenges and obstacles. This approach will require, inter alia, strong scientific evidence, but also specialized resources and funds. And if the scientific community is trying to generate a valid and reliable literature, the necessary funding is not yet considered a priority, as bioactive substances are non-essential! Adding Gaine P.C. et *al.* (2013) in the summary of the symposium [271]. This means that dietary biocompounactives are not yet ready for integration with recommended intakes.

3.2. Processed Foods

In addition, the recommendations provide a wide range of forms of foods, including fresh, frozen, canned and dried food and juices [261, 272]. While many phytochemicals may be transformed or lost during food processing[270]. In general, treatment of fresh foods leads to changes in the composition of bioactive food components. These changes can be beneficial or detrimental to the total content of health-promoting phytochemicals compounds [273].

Methods of food processing may affect the content, activity and bioavailability of bioactive compounds in foods [274]. However, several phytochemicals are destroyed or reduced during processing [275, 276]. For example, the phenolic compounds are generally considered to be relatively stable in storage at a cool temperature, but can be lost or degraded at high temperature [277, 278].

In this context, studies give results that cannot be generalized due to the intervention of several factors simultaneously. In tomatoes (fruits used as vegetables in cooking), for example, the pasteurization at high temperature (98 °C), even for a short time (40 seconds), reduces the content of total phenolic compounds [279]. However, another study reported that phenolics of tomato increased by 23-34% after bleaching at 100°C for 30 minutes [280]. While this increase in phenolic compounds is not always beneficial, it is true that it can be associated with an increase of antioxidant potential, but the oxidation of phenolic compounds may cause undesirable browning during storage of food; as it can be associated with an accumulation of some phenolic compounds such as isocoumarins which may cause a bitter taste [281-283].

Heat treatment is currently the most common method used for domestic and industrial food processing. It is the most widely used method to preserve and extend the useful life of the food [284]. Knowing that the nutritional value and phytochemical content of plant tissue is usually reduced during senescence and normal aging after harvest [285]. However, the thermal techniques have negative effects on biocompounactives in foods. To meet this challenge and ensure food security, while preserving the bioactive compounds, there needs to combined approaches and targeted studies on the stability of biocompounactives. While research shows that non-thermal technologies have the potential to improve the retention of bioactive compounds without compromising food security [286].

Besides the influence of treatment (or transformations) post-harvest, the content of phytochemicals in foods can be influenced by variety, environment and conditions of growth, maturity stages and harvesting factors [287-290], but little information is available on the influence of cultivation factors or genotype [291], while the impact of harvesting techniques and storage phytochemicals began to be explored in relatively recently [277]. In general, most studies on the application of food phytochemicals are limited to the examination of their bioactive efficiency rather than their stability during storage, for example [292].

3.3. Allergic Reactions

Finally, allergic reactions of food-borne are responsible for a variety of symptoms and disorders involving the skin and the gastrointestinal and respiratory tracts [293, 294]. The dose or the amount of food needed to trigger a clinically apparent reaction generally varies between individuals and even in the same individual over time. It also depends on metabolic differences, the concomitant use of drugs, the freshness of food and their preparation [295].

Potatoes, for example, like all plants of the genus *Solanum*, contain toxic glycoalkaloids. These are mainly α-chaconine and α-solanine, which represent 95% of total glycoalkaloids in modern cultivars [296]. When the potatoes are stored at high temperature or at light, the concentration of these alkaloids increases (green tint or spots), and cooking does not destroy these alkaloids [297]. After consumption, several symptoms could be triggered (tingling sensation in the mouth, bronchospasm, gastrointestinal discomfort ... etc.), and a large quantity consumption can lead to serious poisoning that may affect the central nervous system [297, 298].

4. Conclusion

Biocompounactives contain chemicals that are found in small quantities in plants and certain foods (such as fruits, vegetables, nuts, oils and whole grains), they have actions in the body that can promote good health [299].

All scientific studies confirm that a varied and balanced diet, with minimal physical activity, is factor of protection against cancer, cardiovascular disease, osteoporosis, diabetes, obesity and high cholesterol. True that these diseases do not depend exclusively on food, they are also influenced by genetic factors, but if we cannot choose our ancestors, we can choose our food and organize our lifestyle [300]!

In future studies, we continue on preventive approach of biocompounactives that contain fruits (part 2), cereals and some foods of animal origin (part 3), with discussion of other opportunities and challenges facing this approach.

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