Scientific Papers. Series B, Horticulture. Vol. LXV, No. 1, 2021
Print ISSN 2285-5653, CD-ROM ISSN 2285-5661, Online ISSN 2286-1580, ISSN-L 2285-5653

THE ROLE OF FOOD LEGUME SPECIES IN THE CONTEXT OF SUSTAINABLE AGRICULTURE, FOOD SECURITY, AGROBIODIVERSITY, CONSERVATION AND HUMAN HEALTH

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Abstract

The study addresses the major role of grain legumes in relation to the main challenges of agricultural sector as biodiversity conservation, soil fertility, use of resources on agro food chain, human and environment health. The focus was on species Phaseolus vulgaris, Ph. coccineus, Lathyrus sativus, Vigna radiata, Pisum sativum, Vicia faba, Cicer arietinum, Lens culinaris. The study included ample documentation related to recently developed EU new protein plan and H2020 currently developed projects focused on the paramount potential of food legume species in (1) sustainable agriculture - modern (inter)cropping schemes designed to reduce use of external inputs (2) agrobiodiversity and conservation - a vast amount of leguminous genetic resources hosted by different institutes in frame of major collections and strategies to make the resources available and useful for different end user categories (3) food security and human health - human plant protein intake is on the rise in many EU regions, presently is taking place a re-evaluation for useful effects of consumption in the diet, which is the basis for various health

Key words: *biodiversity, Fabaceae, nutritional profile, quality traits, use.*

INTRODUCTION

The world's population is expected to increase. Many people will face global challenges among which achieving food security, lowering the risk of climate change by reducing the net release of greenhouse gases into the atmosphere and solving in a friendly environmental manner the increasing demand for energy.

The global food production request new solutions, natural based as much as possible, to solve the sever impact of different categories of stressors, and to develop the best solutions to ensure enough and safety food and to limit the negative impact of agriculture on environment.

Moreover, since the coronavirus became a pandemic, consumers started buying much more convenient and healthy products, such as beans, chickpea, lentil, rice, and pasta, trying to stay healthy. During look down due to Covid 19 in many places along Europe, the demand for grain products and pulses was increased thanks to their suitability to long term conservation and nutritional profile. The moisture contents of all the dry legumes are in the range of 9-13% making them favorable for long storage. Thanks to their traits, content and characteristics, food legumes and their production systems can play important roles being used for their capacity to deliver multiple services in line with sustainability principles (Stagnari et al., 2017). At global level, grain legumes are introduced in different research programs, being considered the most relevant source of plant protein. These species are largely exploited in many countries of Africa and Latin America, but despite their nutritional and environmental benefits there are some constraints such as a poor adaptation, low resistance to pathogen attack, which severely influenced yield stability and limit species extinction in production system (De Ron, 2015). Despite the benefits of legumes, their status in terms of consumption is different among countries. There are countries where grain legumes are not popular, or consumption is residual. Opposite, there are countries where the consumption and cultivation are extended and encouraged. EU developed a new protein plan, and its implementation will be largely based on traditional and innovative uses of food legumes. The plan highlights the need and the interest of the agri-food sector for development of new products and modern technologies to ensure food security by providing affordable and healthy food, under the pressure of changing climate and socioeconomic conditions. Recently, major advances have been made in the development of single-seed descent (SSD) purified accessions (e.g., AGILE, BEAN_ADAPT, BRIDGE, BRESOV projects), with the possibility to associate phenotypes to reliable genotypic information by few EU projects funded for this aim: LEGATO, EUROLEGUME, LEGVALUE, PROTEINLIFE, PROTEIN2FOOD, BRESOV, ECOBREED. Grain legumes have the potential to contribute more to European agricultural systems by improving the agronomic performance of cropping systems and providing protein-rich food and feed and helping to reduce European dependence on imported protein (Watson et al., 2017). Diet is important, not only for nutrition, but for the prevention and treatment of diseases, especially when these diseases are caused by insufficient, inadequate or unbalanced dietary intake (Muzquiz et al., 2012). Legume seeds contain a great number of bioactive compounds (proteins, tannins, glycosides, saponins, dietary fiber, vitamins). Recent investigations suggest that grain legume may contribute to human health and wellbeing, mostly through prevention of chronic diseases, hypertension, diabetes, cancer, and obesity. Pulses represent an important source of protein for vegetarians, are low glycemic index food and recognized as food choice with significant potential health benefits. They are excellent foods for people managing their diabetes, heart disease or celiac disease, and additionally can help people concerned with weight control. To improve the nutrition of many developing countries, or to combat the incidence of various chronic diseases worldwide, food technologists have developed products based on pulses, adding value thereby contributing to increase in the consumption of legumes (Kamboj & Nanda, 2017; Khang et al., 2016)

MATERIALS AND METHODS

The study represents an ample literature review of the food legumes as key agriculture-related to societal challenges and supports the development of a smart tool aimed to optimize legumes cultivation and their integral use on agri-food chain. The study is developed in frame of nationally and internationally research projects that deals with the urgent need to provide climate-resilient cultivars technics and methods addressed to organic and conventional vegetable production systems. These new resources will benefit growers, seed industry, providing much needed security both under current and future scenarios of climate change. The study is focused on exploit of the genetic variation of legumes species for enhanced productivity, by exploiting up-to-date knowledge of genome structure and function for use in different directions as conservation, human health, sustainable agriculture.

RESULTS AND DISCUSSIONS

Grain legumes represent almost 27% of the world crop production and provide about 33% of the dietary protein consumed by humans. (Smykal et al., 2014). A selected set of food legumes genetic resources representing the diversity available in Europe and world-wide, have been chosen as target species to improve the knowledge related value of the germplasm along the entire value chain of genetic resources, which ranges from conservation and research to breeding and cultivation. These species represent a cross-section in terms of their potential value for sustainable food production, and they are all well linked to the European food tradition, with significant options for EU agriculture. At the molecular level, the species represent extremes regarding their genome sizes and comprehensive panoplies of genomic resources have been developed recently.

Grain legumes and sustainable agriculture - Legumes are adaptable to cultivation under unfavorable ecological conditions, nutritious and stress tolerant, possessing characteristics for enhancing the sustainability of deferent agricultural systems. Despite their high adaptability to semi-arid climatic conditions, pea and faba bean may occasionally be faced with drought stress, depending on the yearly variations in climatic factors, when they are grown as non-irrigated crops. Reduced watering application in faba bean increases the concentrations of crude protein and carbohydrates in seeds. Pea responds to water deficit mainly by immediate abortion of reproductive organs which results in reduced number of seeds per plant rather than by adverse efects on the mean seed weight or on other quality characteristics (Ntatsi et al., 2018). The modern cropping schemes designed to reduce use of external inputs and to exploit legumes thanks to their capacity to fix the atmospheric nitrogen, release in the soil high-quality organic matter and facilitate soil nutrients' circulation and water retention are developed to reduce the negative impact of agriculture on environment; Currently, the European Union devotes only 3% of its arable land to protein crops, and imports more than 75% of its plant protein (EC Report COM (2018) 757 final). The main reasons for this fact are low yield capacity and lack of breeding efforts for adaptation of legumes to European agro-ecosystems. The low level of European plant protein self-sufficiency is due to the late development and adaptation of protein plants in Europe (COPA-COGECA report, GOL (18)585). Better use of genetic resources represents a precondition to increase sustainability. Until about 1970, common bean (*Phaseolus vulgaris* L.) was the most widely cultivated grain legume in Europe. Following the introduction of policy support for soybean and protein feed crops in the 1970s, field pea and soybean became the most widely grown grain legumes (Zander et al., 2016). The main pulses are field peas and faba beans, whereas lentils and chickpeas are only grown on limited areas (EC Report COM, 2018). Pea is the most widely grown grain legume in Europe, but it suffers from poor standing ability, poor ground coverage, and low competitive ability against weeds, along with relatively low protein (20%–24%) and, on many soils, low productivity. Faba bean is the second in area, the first in yield per hectare, and on account of its higher protein content (28-32%), the highest in protein yield, but is adapted to heavy or clay-rich soils and too sensitive to water deficit on sandy soils. Lentil, chickpea, and common bean all have protein contents in the same range as that of pea and have relatively low yields, but high values as they are primarily food rather than feed crops (Watson et al., 2017). Since 2013 production has almost tripled in the EU and reached 6 million t (2.6 million ha) in 2018. Thanks to their capacity to fix nitrogen in soils by synergic relationships with *Rhizobium* and mycorrhizal fungi, legumes help to reduce the need for fertilizers and avoid economic inputs and environmental impacts. The amount of nitrogen fixed by legumes depends not only on species and cultivar but also on environmental factors such as temperature, water availability (Watson et al., 2017). This nitrogen is being utilized through the plant to compose protein which becomes available to humans (Kamboj & Nanda, 2017; Kouris & Belski, 2016). Other benefits of legumes, which should not be ignored, include reduced pest and weed occurrence, and improved soil quality (Kessel, & Hartley, 2000). To cover the increasing amounts of nitrogen requirements during formation and filling, pods attract nitrogen from the nodules. If the nodules cannot cover their N requirements, pods attract nitrogen from older leaves, thereby reducing the photosynthetic capacity of the plants and determining rapidity of ripening. Different studies showed the paramount role of *Rhizobium* strains selection. An increased nodulation capacity may improve N availability to pods, and the effect can be quantified in pod quality by increasing pod size. Selection of efficient bacteria requires specific selection processes based on efficiency and competitiveness for nodulation of the associations (Ntatsi et al., 2018). Salinity is a common and most severe environmental stressor in agriculture, which is dramatically exacerbated by irrigation. Additionally, erroneous fertilization schemes contribute to salt accumulation in plant rooting zone. Under these circumstances the use of commercial inoculants containing arbuscular mycorrhizal fungi is quickly expanding, rewarded as an environmentally friendly technology which contributes to the alleviation of the negative effects of soil irrigation water salinity (Meca et al., 2017). For a while intercropping was ignored by modern techniques focused on standardized products and remained widely applied in low-input and low-yield farming systems and in developing countries. Despite several recognized beneficial aspects of intercropping such as better pest control, competitive yields with reduced inputs, pollution mitigation, reducing the need for fertilizer-N, increasing the utilization efficiency of available nutrients and water, more stable aggregate food or forage yields per unit area, there are a number of constrains that make intercropping not common in modern agriculture, such as example the request of a single and standardized product and the suitability for mechanization or use of other inputs as a prerogative in intensive farming system (Kessel & Hartley, 2000; Aziz et al 2015). It is therefore necessary to optimize intercropping systems to enhance resource-use efficiency and crop yield simultaneously, while also promoting multiple ecosystem services. Most recent research has focalized on the potential of intercropping in sustainable productions and on grain legumes that can fix nitrogen through biological mechanisms. Legumes (top 10 most frequently used intercrop species, seven are legumes) can contribute up to 15% of the N in an intercropped cereal, thus increasing biomass production and carry-over effects, reducing synthetic mineral N-fertilizer use and mitigating N_2O fluxes (Stagnari et al., 2017.) When maize and beans are intercropped, their yields are generally lower than those of maize or beans grown in monoculture. Studies have found that maize yielded 5.3 t ha^{-1} when monocropped, 5.2 t ha^{-1} when intercropped with bush beans, and 3.7 t ha^{-1} when intercropped with climbing beans. Maize-legume rotations also help to maintain soil fertility (FAO, 2016). Different studies developed in H2020 projects showed that some intercropping schemes are not competitive, species as onion and faba bean, being in competition for moisture and nutrients. The detrimental effect of this competition impairs mainly onion, especially when grown under unfavorable conditions (high temperature and low precipitation). Other conclusions highlighted the fact that carrot and faba bean plants compete and share available soil resources. A comparative study showed that carrot yield in intercropping variant was 2.28 kg m^{-2} and did not differ significantly from the control variant developed without N fertilization. Complex studies developed by researchers in frame of EUROLEGUME project showed the fact that cabbage is suitable for intercropping with faba bean without yield losses. (Lepse et al., 2017). Cereal–legume intercrops can be used for forage or grain depending on growing conditions and farm management and using them for whole-crop silage is a way of boosting the forage protein content of livestock diets. The cereals are generally better than legumes at taking up mineral N. Legume root exudates liberate phosphate and several cation species, and the cereal roots liberate other nutrients, leading to increases in the P uptake of cereals and Fe and Zn uptake of legumes compared to sole crops. The advantage of cereal-legume mixtures over pure cereals is generally greater in systems with little or no usage of nitrogen fertilizer. Chemical weed control is difficult or impossible in intercrops, as few herbicides are tolerated by both a cereal and a legume (Watson et al., 2017). Intercropping grain legumes and cereals has demonstrated multiple agronomic and environmental benefits, all listed in the final report of LEGATO project.

One significant effect of intercropping versus grain legume sole crops consists in increased capacity to reduce weed abundance. This, together to decreased severity of pest or disease problems, leaded to accomplishment of stable grain and cereal yields, increased biodiversity able to support pollinating insects, according to data reported and retrieved form http://www.legato-fp7.eu/, in frame of LEGATO project.

Grain legumes are weak suppressors of weeds but mixing species in the same cropping system could represent a valid way to improve the ability of the crop itself to suppress weeds (Stagnari et al., 2017). A mixture of the two varieties of pea can reduce weeds compared to sole crop of semi-leafless pea, and whether this benefit can be obtained in synergy with reduced lodging compared to sole crop of normal leafed according to data reported and retrieved form http://www.legato-fp7.eu/, in frame of LEGATO project.

Grain legumes significantly reduced their emission factors suggesting that legume-fixed N is a less-emissive form of N input to the soil than fertilizer N. Legumes have a proven role in reducing GHG in accord to the management of agro-ecosystems in which they are included. Results reported by (Senbayram, 2016; Jensen,

2012) showed that faba bean grown as mono cropping, led to threefold higher cumulative N_2O emissions than that of unfertilized wheat; when faba bean was intercropping with wheat, cumulative N_2O emissions fluxes were 31% lower than that of N-fertilized wheat. There is also some interest in intercropping legumes with oil crops, such as pea with linseed (*Linum usitatissimum* L.) or faba bean with either safflower (*Carthamus tinctorius* L.) or mustard (*Sinapis alba* L.) (Watson et al., 2017). Direct mutual benefits in cereal-legumes intercropping involve below-ground processes in which cereals while benefiting of legumes-fixed N, increase Fe and Zn bioavailability to the companion legumes. Higher yields are therefore observed for crops following legumes e.g. yields of wheat, maize or rapeseed can be up by 10 % compared to following a cereal. The quality of cereals is also improved (e.g. higher protein contents or lower mycotoxins contamination) when following a legume (EC Report COM, 2018). Studies and results related large insertion of legumes in farm rotations, crop management practices (planting time, densities, fertilization, soil management, weeding, irrigation), need to be implemented and harmonized as standard techniques to be applied by farmers.

Agrobiodiversity and conservation - In Europe, the Common Agricultural Policy (CAP) has driven the intensification of agriculture, promoting the simplification and specialization of agroecosystems through the decline in landscape heterogeneity, the increased use of chemicals per unit area, and the abandonment of less fertile areas (Emmerson et al., 2016). High-input farming practices directly affecting biodiversity, such as herbicide application or monocultures, may disrupt potential pest control services (Pappagallo et al., 2018). A significant challenge is to solve the impact of erosion of agricultural genetic diversity which is reported at global level. Numerous publications and debates over several decades have been devoted to the impact of genetic erosion on resilience to climatic, economic, or societal context. There are several cases where lack of within crop diversity has resulted in substantial production losses. Crop's diversification can ensure benefits for environment and along agri-food chain. Legumes have an impact on breeding - pre breeding, screening of a rich genetic material, investigating genetic resources will ensure the creation of a valuable breeding material, used to improve the productive and qualitative potential, resistance to biotic and abiotic stress; nutritional profile; antioxidant capacity; The characterization and maintenance of food-legume genetic resources, and their exploitation in pre-breeding, can play a significant role not only in a sustainable agriculture but also in entire agri-food chain, by providing healthier food products. Need for improvement of food legume genetic resources: to date, exploitation of genetic resources in crop breeding is limited in comparison to availability of materials, and the potential impact of their use is far from optimal (i.e., lack of comprehensive information regarding passport data and descriptors useful for users, accession heterogeneity, unharmonized data), which also affects ability to attract funds for genetic-resources conservation. These issues are more critical in food legumes, as breeding investment and research activities remain modest. Efficient genetic-resources management is required to attract additional private and public investment to boost food legumes breeding. From this perspective, the availability and access to well-described and well-managed genetic-resource collections of food legume species that capture the full diversity range will be paramount to advance legume crops and to reach a competitive level in the EU regarding agronomic performance and sustainability. Indeed, without correct handling of EU legume genetic resources, the European Commission's goal of achieving the nine CAP objectives (i.e., economic, environmental, climatic and socio-economic, including healthier diets) will be unattainable (EC Report COM, 2018). According to INCREASE an H2020 ongoing project, the actual utilization of grain legumes GenRes is limited in comparison to the availability of materials and the potential impact of their use, due to several concurrent factors: *a) genetic structure of accessions* - in most cases, accessions have unknown genetic structure and are heterogeneous, which impedes the projection of the phenotypic information to the genotype and vice versa. *b) limited information availability on GenRes*:

large numbers of accessions have only minimal, if any, information regarding biological status and geographic origin; information regarding traits of interest for breeders and users is very low and mostly limited to morphological descriptors; *c) limited access to available information* (*) the heterogeneous nature and non-standardized way of data collection and integration causes that a huge amount of information is heavily under-used; (**) databases are centralized and not designed to integrate data obtained by external users strongly limiting the access to available information; (***) the available information is not easily accessible to users due to unfriendly searching and visualization tools. Collections are assembled and are maintained on an accession basis, where each accession usually comprises a mixture of genotypes that represent a population. The conservation of the population represents substantial challenges that arise from genetic drift and/or selection, which are difficult to fully address in conventional conservation management, and from the lack of knowledge of their diversity. A survey accomplished in INCREASE proposal presented the actual status of some grain legumes collections, according to different sources. Based on GENESYS data retrieved from https://www.genesys-pgr.org the largest collections of chickpeas are maintained at ICARDA and ICRISAT, centers of CGIAR with unique accessions estimated at more than 15,000 and 20,000, respectively. The largest collection of wild materials and derived introgression lines is maintained at UC Davis in California. Regarding the availability of common bean GenRes, based on GENESYS data the most important *P. vulgaris* collections are maintained at Centro Internacional de Agricultura Tropical (CIAT) and USDA-ARS, at Washington State University (USA), with more than 24,000 and 18,500 accessions, respectively. In Europe large collections are conserved at Leibniz Institute of Plant Genetics and Crop Plant Research-IPK (~8,500 accessions). There are currently over 58,000 lentil accessions held in various genebanks worldwide. Genesys displays information for about 70% of these (https://www.genesys-pgr.org). ICARDA, with 12,463 accessions, is the center with the largest lentil collection. Genetic improvement of nutritive value can modify the content of bioactive compounds. For this reason, it has been possible to genetically eliminate the alkaloids in different species of *Lupinus* and decrease vicine and convicine in *V. faba* by breeding.

***Legumes a bridge between food and health* -** Global diets have considerably changed in the last decades and more attention is paid by majority of countries to these implications. More calories are being consumed per person, and the proportion of fat and animal protein consumed has increased significantly with wealth (Williams, 2020). Diet is now recognized as important, not only for nutrition, but for the prevention and treatment of diseases, especially when these diseases are caused by insufficient, excessive or unbalanced dietary intake. One of the most controversial subjects of discussion is the establishment of an optimum human diet. Grain legumes are featured by superior quantity of protein comparing with other plant foods and have twice the dietary protein content of cereal grains (Kouris-Blazos & Belski, 2016), strongly having perspective to exploited against malnutrition and generally in food sector. Recent investigations suggest that grain legumes, beside their beneficial role on environment may contribute to human health and wellbeing, mostly through prevention of chronic diseases. The most frequent diseases linked with unhealthy diets are the coronary heart disease, obesity, hypertension, diabetes, and cancer. Consumption of legumes reduces the risk of cardiovascular disease, some cancers and helps to manage body weight due to its satiety value (Kamboj, 2017). Consumption of common beans contributes to the prevention and/or treatment of degenerative-chronic diseases, such as obesity, diabetes, cancer, cardiovascular diseases, partly due to the influence of micronutrients (mainly folic acid and magnesium) and high fiber content, condensed tannins, phytoestrogens, and non-essential amino acids. Common beans are a good source of aromatic amino acids, lysine, leucine, and isoleucine, but deficient in sulfur amino acids (methionine and cysteine), valine, tryptophan and threonine (De Ron et al., 2015). Vicine and convicine are natural pyrimidine glucosides found in the faba bean plant and are likely to be involved in plant defense mechanisms against pathogens. Recent papers suggest that faba bean and derivatives could represent a suitable food in treatment of diabetics, in hypertension and may help to prevent cardiovascular disease (Turco et al 2016). Among micronutrients, peas have high ascorbic acid, β-carotene, thiamine, and riboflavin contents and compared with other vegetables, they are rich in iron (20.2 μg^{-1} of the edible portion). Peas, like beans, lentils, and chickpeas, are also good sources of folate, the vitamin that lowers the blood level of homocysteine. Legumes seeds contain a great number of bioactive compounds that vary considerably and can be proteins (protease inhibitors, a-amylases, lectins), glycosides, tannins, saponins or alkaloids (Muzquiz et al, 2012). Their physiological effects are diverse: pyrimidine glycosides present in *Vicia faba* are the causative agents of favism; the non-protein amino acid b-N-oxalyl-L-a,b-diaminopropionic acid (b-ODAP) contained in the seeds of *Lathyrus* spp. can cause neurolathyrism. Some other bioactive compounds detected in grain legumes, as for example a-galactosides are associated with capacity to induce flatulence. Despite the negative role in consumption, inducing digestive discomfort, some of these bioactive compounds have a positive and supportive role for plants in their defense mechanisms. Published studies pointed out the role to strengthen plants behavior against predators or unfavorable environmental pressure. Pulses represent an important source of protein for vegetarians, are low glycemic index food and recognized as food choice with significant potential health benefits. They are excellent foods for people managing their diabetes, heart disease or celiac disease, and additionally can help people concerned with weight control. To improve the nutrition of many developing countries, or to combat the incidence of various chronic diseases worldwide, food technologists have developed products based on pulses, adding value thereby contributing to increase in the consumption of legumes (Khang et al., 2016). A plenty of studies highlight the essential amino acids in legumes fact that make them available for different combination with cereals in daily intake. The presence of calcium, magnesium, potassium, phosphorus, and iron was also detected in legume seeds. Bioavailability of nutrients can be increased by soaking, sprouting and fermentation (Kamboj & Nanda, 2017). Grain legumes contain 20-45% protein compared with 7-17% in cereals. The protein content ranges from 20% to 25% in common bean (*Phaseolus vulgaris* L.), lentil (*Lens culinaris* Medik.), and pea, to over 40% in soybean and yellow lupin (*Lupinus luteus* L.) (Watson et al., 2017). On the other hand, legumes are considered to have incomplete proteins (except soy) because they contain relatively low quantities of the essential sulphur containing amino acids cystine, methionine and cysteine (which are found in higher quantity in grains). However, grains contain relatively low quantities of lysine, whereas legumes contain appreciable quantity (Kamboj & Nanda, 2017). Studies to investigate the variation of protein content in different organs of same species showed that the highest protein content was detected in seeds, and lower in pods and immature seeds. The nutritional value of legume vegetables as protein sources depends not only on their protein content but also on the amino acid composition and the protein digestibility (Ntatsi et al., 2018). Adequate dietary fiber is vital for proper working of the gut, which is related to reduce risk of several chronic diseases including certain cancers, heart disease and diabetes. Fiber comprises pectin, mucilage, cellulose, gum, hemicelluloses and lignin. Most of the legume grains which are consumed as pulses by humans, their fiber content ranges from 0.9-5.3%. Legumes are mainly rich in resistant starch (RS), have low glycaemic index carbohydrates. The oligosaccharides (mainly raffinose and resistant starch) and fiber pass through the stomach and small intestine in the undigested form until they reach the colon, where they act as food (prebiotics) for the probiotic or beneficial bacteria which resides there. This bacterial fermentation leads to the development of short-chain fatty acids, such as butyrate, which possibly will improve colon health through promoting a healthier gut micro biome and reducing colon cancer risk. They also play a positive role in weight reduction due to its satiety value. In addition, they are capable to help in moderating blood sugar levels after meals and improve insulin sensitivity (Trinidad et al., 2009). Commonly consumed legumes having carbohydrate content in the range of 20.9-60.9%. In legume seeds, starch is the main source of accessible carbohydrate and most plentiful 22-45% along with 1.8-18% oligosaccharides and 4.3-25% dietary fiber (Kamboj & Nanda, 2017). Legumes are excellent source of iron, calcium, zinc, selenium, magnesium, phosphorus, copper, and potassium. Cereals grains generally supply the higher energy and make up the volume of diets. As sources of micronutrients legumes are superior to cereals because legumes have higher initial minerals content. Most legumes, including common beans are consumed whole, resulting in conserving their mineral contents (Trevor et al., 2003). Micronutrient deficiencies have become more common, even in developed countries. Legumes are superior source of vitamin B-complex but are a poor source of vitamin C and fat-soluble vitamins. Legumes are normally low in fat and have no cholesterol, with soybeans and peanuts exception. Mono and poly unsaturated fatty acids decrease the possibility of coronary heart diseases (Kamboj & Nanda, 2017). Legumes have anti-nutritional factors which affect its nutritional quality. Anti-nutritional factors can decrease palatability and diminish protein digestibility and bioavailability of nutrients. Several usually considered antinutritional compounds like phytic acid, phenols and tannins are currently considered as potential antioxidants containing health promoting effects. Phytochemicals reduce the digestion and absorption of nutrients or interfere with their action. The bioactive phytochemicals including enzyme inhibitors are mainly represented as phytoestrogens, oligosaccharides, phytosterols, phytates, saponins, flavanoids and phenolic acids (Kouris & Belski, 2016). Grain legumes are the main sources of lectins in human food. Lectins from some of the pulses can reduce the digestibility and biological value of dietary proteins. (Muzquiz et al., 2012) demonstrates that lectins may be beneficial by stimulating gut function, limiting tumor growth, and ameliorating obesity. The significance of phenolic compounds was gradually recognized, and several studies have now reported that phenolics offer many health benefits and are vital in human nutrition. Some studies investigated and reported correlations between phenolic compositions and antioxidant activities. Pulses with highest total phenolic content (lentil, red kidney, and black bean) exert the highest antioxidant capacity (Singh & Basu, 2012). Saponins have been reported in many pulses, lupin, lentil, and chickpea, as well various beans, and pea (Kamboj & Nanda, 2017). Recent evidence suggests that saponins possess hypocholesterolemic, anticarcinogenic and immune stimulatory properties. The antioxidant properties of food have been extensively studied since excessive production of free radicals/reactive oxygen species (ROS) and lipid peroxidation are widely believed to be involved in the pathogenesis of many diseases. The most common diseases are cardiovascular diseases, cancers, autoimmune disorders, rheumatoid arthritis, various respiratory diseases, cataract, Parkinson's or Alzhemier's diseases and ageing. Sprouts (including *Vigna* sprouts) are assumed to be good sources of these natural antioxidants and hence can be exploited in food, pharmaceutical and cosmetic industry (Tomar et al., 2018). The market for pulses for food in the EU is benefitting from innovations in pre-cooking processes, inclusion of pulses in prepared convenience foods and the development of new pulses such as 'edamame' (European Commission, 2018). In the case of extruded legumes, which have high protein content, could be the base material for the development of high protein snack bars, since taste is sufficiently neutral, and so they can be used for salty or sweet preparation. An added value can be given by adding functional supplements such as hemp seeds, goji berries, ginger, and others as reported by EUROLEGUME project. The introduction of legume flour into cereal products can therefore increase the protein, insoluble fiber, vitamin, and mineral contents. Considering the results of ongoing and or already developed projects and also screening the market we many innovative products based on legumes can be easily identified: immature seeds of peas and beans with extended shelf-life, pesto sauce made from fresh faba bean seeds, cowpea fresh pods as a novel legume vegetable, faba bean 'cheese, ready-to-eat-pulse spreads, extruded snacks made from dry pea and bean seeds, and protein and fiber rich legume bars with various flavors, according to new developed products in frame of EUROLEGUME project. Faba bean can be an ingredient for beer. In 2016, the new Bean Beer was introduced as a beer made with 40 % whole faba beans and 60% malted barley. The beer is marketed as a sustainable drink made as it is made from a crop that contributes to more sustainable farming practices (Hamann, 2019). There are new opportunities of using legumes for food products of improved nutritional value.

CONCLUSIONS

Legumes represent a valuable source of food proteins, and their exploitation is expected to increase in relation of a growing world's food need. The actual context of the need for available, healthy, long self-life food, new opportunities and challenges for the agriculture and food sector open. The value chain needs a strong improvement with new varieties with higher adaptation to different environments, better yield, and improved qualities with a particular concern in the development of new products with high organoleptic and nutritional value. The availability of novel varieties will facilitate the adoption of food legumes in the agroecosystem improving the agrobiodiversity with all its related positive consequences associated to the inclusion of legumes in the cropping systems (e.g. sustainability, food security, economic returns, stable farming systems, increase of soil fertility, diversify products, improve human nutrition, etc.).

For the sustainable use of genetic resources, a coordinated, interdisciplinary, and multi-sectorial effort is needed to exploit the recent scientific and technological ground-breaking advances. Future strategies need to focus on the sustainable re-introduction of grain legumes into crop rotations, based on their positive effects on yield and quality characteristics on subsequent crops.

ACKNOWLEDGEMENTS

This work was supported by BRESOV project which has received funding from European Union's HORIZON 2020 research and innovation programm under GA no 7742 44. a grant of the Romanian Ministery of Research and Innovation, CCCDI - UEFISCDI, project number PN-III-P1-1.2-PCCDI-2017-0850/ contract 14 PCCDI /2018, within PNCDI III, and ADER 2020 projects developed by VRDS Bacau.

REFERENCES

Aziz, M., Asif, M., Athar, M., and Abbas, A. (2015). Wheat-based intercropping A review. *Journal of Animal and Plant Science, 25(4)*. 896-907.

COPA-COGECA report, GOL (2019). *Cereals: a major source of plant protein, (18)*585 Brussels.

De Ron, A.M. (2015). *Grain Legumes. Handbook of Plant Breeding*. Springer. pp.1-2.

EC Report COM (2018). 757 Development of Plant Proteins in the European Union *Final Report from the Commission to the Council and the European Parliament,* 1-16.

Emmerson, M., Morales, M., Oñate, J., Batary, P., Berendse, F., Liira, J., Aavik, T., Guerrero, I., Bommarco, R., Eggers, S., Pärt, T., Tscharntke, T., Weisser, W., Clement, L., Bengtsson, J. (2016). How Agricultural Intensification Affects Biodiversity and Ecosystem Services. *Advances in Ecological Research*, *55*. 43-97.

Hamann, K. (2019). Best practices for the commercialisation of legumes, Transition paths to sustainable legume-based systems in Europe (TRUE).

Jensen ES, Peoples MB, Boddey RM, Gresshoff PM, Hauggaard-Nielsen H, Alves BJ, Morrison MJ. (2012). Legumes for mitigation of climate change and the provision of feedstock for biofuels and biorefineries. A review. *Agronomy for Sustainable Development, 32*. 329–64.

Kamboj, R., Nanda, V. (2017). Proximate composition, nutritional profile and health benefits of legumes – A review. *Legume Research*, 4-6.

Kessel, Van, C. and Hartley, C. (2000) Agricultural Management of Grain Legumes: Has It Led to an Increase in Nitrogen Fixation? *Field Crops Research*, *65*, 165-181.

Khang, D.T., Dung, T.N., Elzaawely, A.A., and Xuan, T.D. (2016). Phenolic Profiles and Antioxidant Activity of Germinated Legumes. *Foods*, *5(2)*. 27.

Kouris-Blazos, A., Belski, R. (2016). Health benefits of legume and pulses with a focus an Australian seet lupins. *Asia Pacific Journal of Clinical Nutrition*, *25(1)*. 1-17.

Lepse, L., Dane, S., Zeipina, S., Domínguez-Perles, R., and AS Rosa, E. (2017). Evaluation of vegetable-faba bean (*Vicia faba* L.) intercropping under Latvian agro-ecological conditions. *Journal of the Science of Food and Agriculture, 97(13)*. 4334–4342.

Meca, E., Sallasku, G., and Baliu, A. (2017). Could the artificial inoculation of AM fungi improve the benefits of using pea (*Pisum sativum* L.) plants for soil amendment purposes in greenhouses. *Acta Horticulturae,* 1164, 233.

Muzquiz, M., Varela, A., Burbano, C., Cuadrado, C., Guillamón, E., and Pedrosa, M.M. (2012). Bioactive compounds in legumes: pronutritive and antinutritive actions. Implications for nutrition and health. *Phytochemistry Reviews, 11*. 227–244.

Ntatsi, G., Gutiérrez-Cortines, M.E., Karapanos, I., Barros, A., Weiss, J., Balliu, A., and Savvas, D. (2018). The quality of leguminous vegetables as influenced by preharvest factors. *Scientia Horticulturae*, *232*. 192-199.

Pappagallo, S., Brandmeier, J., and Scherber, C. (2018). Effects of agrobiodiversity on pest control in *Vicia faba* L. EUCARPIA Symposium on Breeding for Diversification. Witzenhausen 82.

Senbayram M, Wenthe C, Lingner A, Isselstein J, Steinmann H, Kaya C, Köbke S. (2016). Legume-based mixed intercropping systems may lower agricultural born N_2O emissions. *Energy, Sustainability and Society, 6*. 2.

Singh, J., Basu, P.S. (2012). Non-Nutritive Bioactive Compounds in Pulses and Their Impact on Human Health: An Overview. *Polish Journal of Food and Nutrition Sciences*, *03(12)*. 1664-1672.

Smykal, P., Coyne, C., Ambrose, M., Maxted, N., Schaefer, H., Blair, M., Berger, J., Greene, S., Nelson, M., et al. (2014). Legume Crops Phylogeny and Genetic Diversity for Science and Breeding. *Critical Reviews in Plant Sciences*, *33*. 43-104.

Stagnari, F., Maggio, A., Galieni, A., and Pisante, M. (2017). Multiple benefits of legumes for agriculture sustainability: an overview. *Chemical and Biological Technologies in Agriculture*, *4(2)*. 1-9.

Tomar, S., Chauhan, G., Das, A., and Verma, M.R. (2018). Comparative Evaluation on Phenolic Content and Antioxidant Activity of Legume Sprouts as Affected by Various Solvents for Application in Livestock Products. *International Journal of Current Microbiology and Applied Sciences*, *7(5)*. 3389-3395.

Trevor L. Wang, Claire Domoney, Cliff L. Hedley, Rod Casey, Michael A. Grusak, 2003, Can We Improve the Nutritional Quality of Legume Seeds? *Plant Physiology,* 886-887 www.plantphysiol.org.

Trinidad, P., Mallillin, A.C., Loyola, A.S., Sagum, R.S., and Encabo, R.R. (2010). The potential health benefits of legumes as a good source of dietary fibre. *British Journal of Nutrition*, *103*. 569–574.

Turco. I., Ferretti, G., and Bacchetti, T. (2016). Review of the health benefits of Faba bean (*Vicia faba* L.) polyphenols. *Journal of Food and Nutrition Research, 55(4)*. 283-293 https://scholar.google.com.

Watson, C., Reckling, M., Preisse, S., Bachinger, J., Bergkvist, G., Kuhlman, T., Lindstrom, K., Nemecek, T., Topp, C.F.E., Vanhatalo, A., et al. (2017). Grain Legume Production and Use in European Agricultural Systems. *Advances in Agronomy,* 237-284 https://www.researchgate.net

Williams, M. (2020). The Environmental Assessment of Diets, Deliverable (D): 5.5 (D33) (7p). Transition paths to sustainable legume-based systems in Europe (TRUE).

Zander, P., Amjath-Babu, T.S., Preissel, S., Reckling, M., Bues, A., Schläfke, N., Kuhlman, T., Bachinger, J., Uthes, S., Stoddard, S., et al. (2016). Grain legume decline and potential recovery in European agriculture: a review. *Agronomy for Sustainable Development, 36(2)*. 3-15.

https://www.genesys-pgr.org/welcome.

https://eur-lex.europa.eu.

www.fao.org. Food and Agricultural Organization. (2016).

http://www.legato-fp7.eu/.

https://cordis.europa.eu/result.

http://www.eurolegume.eu/.

https://npgsweb.ars-grin.gov.