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Review

Leveraging traditional crops for better nutrition and health - The case of chickpea

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A R T I C L E I N F O

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A B S T R A C T

Background: Adequate nutrition in early life is a prerequisite for human capital formation and economic development. Although poor feeding practices is a problem predominantly thought to exist in low-income and middle income countries, **malnutrition** is rapidly rising among developed nations as well. In this context, and in light of scarcity of protein sources, utilization of crops-such as chickpea-as a source of micro and macro nutrients is mandatory in the long route to nutritional improvement.

Scope and approach: In this review, we outline interesting features of the **chickpea** crop, in terms of its **nutritional value** and **agronomic potential** that may help combat several health issues in both Western countries as well as in many low income sectors in developing countries.

Key Findings and Conclusions: On the global scale, chickpea consumption is steadily increasing in recent years. In developing countries, chickpea brings a variety of taste and texture to the cereal-based diet, as well as **high-quality protein**, fiber, carbohydrates and minerals, thereby ensuring a balanced diet and improving the nutritional status of the population. In developed countries, chickpea may be an ultimate source of protein for the increasing vegetarian/vegan populations. On top of that, allergenicity issues, content of phytoestrogens and more, are negligible in chickpea. For all these reasons, this crop should be considered as an outstanding source of protein, the ultimate alternative to soybeans, as well as the **next health-food** for human consumption.

1. Preface

On the global scale, chickpea (*Cicer arietinum* L.) consumption is steadily increasing in recent years (FAO, 2013). Demand for chickpea grain in highly industrialized nations and in developing countries is reflected in the global production figures. Until several years ago chickpea ranked third (after dry beans and dry pea), but in recent years the global production of chickpea is higher than that of dry pea (FAO, 2013). Currently chickpea is being grown on 12–13 million hectares yielding about 11–13 million tonnes of grain. In terms of its nutritional value and agronomic potential this pulse crop offers many interesting features that may help combat several health issues in both Western countries as well as in many low income sectors in developing countries, such as malnutrition and scarcity of protein sources (Esnouf, Russel, & Bricas, 2011) In this review we wish to outline the potential of this versatile crop both from an agronomic and from nutritional perspectives.

2. History and agronomy

Chickpea is a traditional staple protein crop across the Mediterranean basin, the Middle East, Central Asia, the Indian subcontinent and East Africa (FAO, 2013; Vavilov, 1951, pp. 13–54). Following the Columbian contact it was introduced to the New World (Harlan, 1992; G.; Ladizinsky, 1998) and in the last several decades it became an important crop also in Australia (Siddique & Sykes, 1997).

Few morphological characters are commonly used for classification of chickpea into two main cultivar groups. The desi type, grown mainly in the Indian subcontinent and East Africa (where 75% of the global production currently take place), is characterized

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by pink flowers and small (100- to 200-mg), usually angular, and yellow-brown- (or other) colored seeds and bushy growth habit. The kabuli type, native to the Mediterranean and Near-East region, possess white flowers and large (200- to 680-mg) smooth or wrinkled light-colored seeds are usually more robust and mostly late flowering. It is believed that kabuli chickpea was introduced into India through Afghanistan in the mid-to late 17th century (J. Kumar & Abbo, 2000).

Chickpea was domesticated in southeastern Turkey alongside the other Near Eastern grain crops (Lev-Yadun, Gopher, & Abbo, 2000; Zohary, Hopf, & Weiss, 2012), and its wild progenitor is a rather rare species, *C. reticulatum* Ladizinsky with restricted natural distribution (G. Ladizinsky & Abbo, 2015). Most chickpea cultivars are susceptible to Ascochyta blight caused by the fungal pathogen *Didymella rabiei*. The propagules of this pathogen spread via rain-splash and infection is positively correlated with air humidity and leaf wetness (D. E. Shtienberg, Gamliel-Atinsky, Brener, & Dinoor, 2005). Therefore, chickpea crops grown during the rainy season are likely to suffer severe yield losses (Nene, 1982). To escape the risk of Ascochyta epidemic traditional farmers throughout the Mediterranean basin, the Middle East and Central Asia have grown chickpea as a spring-sown crop (J. Kumar & Abbo, 2000). Considerable progress was made in breeding Ascochyta resistance cultivars in several countries including Canada, USA, Spain, Israel and by ICARDA (Lichtenzveig, Bonfil, Zhang, Shtienberg, & Abbo, 2006; Rubiales & Fondevilla, 2012). In parallel, modern management packages were developed to enable winter cropping of chickpea, thereby making a significant grain yield progress (Bonfil, Goren, Mufradi, Lichtenzveig, & Abbo, 2007; D.; Shtienberg, Vintal, Brener, & Retig, 2000). It is anticipated that such efforts will enable farmers to improve grain yield even further.

Since the wild progenitor of the crop is a winter annual, the ancient shift from a wild winter annual into a spring-sown crop required a major adaptive change, namely selection in favour of alleles conferring vernalization insensitivity that enable timely flowering before the onset of the summer drought (Abbo, Berger, & Turner, 2003; Abbo, Lev-Yadun, & Galwey, 2002; Abbo, Shtienberg, Lichtenzveig, Lev-Yadun, & Gopher, 2003). The physiological shift (into a spring-sown crop) facilitated the ancient spread of chickpea into the highlands of east Africa and the Indian sub-continent where it was assimilated as a post-Monsoonal crop into the local agro-eco-systems (S. Abbo et al., 2003).

Wheat, barley, pea, lentil and flax also originated alongside chickpea in the Neolithic Near East (Zohary et al., 2012). However, unlike chickpea the growth cycle of these crops did not undergo a major shift (from winter to spring cropping), hence in terms of adaptation to the growth seasons, both winter and spring types are available in wheat, barley, pea, and flax. Consequently these crops can be grown in a wide agro-ecological range from near equatorial regions to temperate high latitude zones. As outlined above the evolutionary history of domesticated chickpea poses severe limitation to its present-day adaptation and limits its yield potential in many world regions (Abbo et al., 2009; Berger & Turner, 2007). However, recent work on vernalization response suggests that there exists a potential to widen the adaptive range of chickpea beyond its present limitations into the temperate zone in winter wheat based agroecosystems (Pinhasi van Oss et al., 2015). We take this as a hint that similar to the achievements of soybean and common bean breeders, it should be possible to further widen chickpea adaptation provided the right germplasm is recruited.

Undernutrition is highly prevalent in low income and middle-income countries, resulting in substantial increases in mortality and overall disease burden. Nearly 805 million people of the 7.3 billion people in the world, or one in nine, were suffering from chronic undernourishment in 2012–2014 (FAO, IFAD, & WFP., 2014). Children are the most visible victims of undernutrition. Poor nutrition plays a role in at least half of the 10.9 million child deaths each year (five million deaths) (FAO et al., 2014). Profitable chickpea cropping as well as local production of special foods based on its grains by subsistence farmers in developing countries, where vitamin A and essential minerals deficiency is prevalent, could be a powerful tool in the hands of local governments, international aid agencies and policy maker at all levels. Sustainable production of high-quality and nutritious chickpea-based foods in locally-run processing plants in remote rural areas should rely on local grain production. Therefore, there is a need to develop an adequate agronomic infrastructure in terms of adapted cultivars, and management packages to ensure stable yields with minimal inputs and to minimize losses in storage, field damage from pests, soil- and air-borne diseases, parasitic weeds, and drought. The underlying rationale is that sustainable demand by processing facilities matched by sustainable supply from local farmers will create a stable source of income for local farmers and hence, further improve their standard of living. This will benefit subsistence farmers who may gain access to this new market.

Accordingly, in the following sections we outline the nutritional aspects and highlight progress made in the utilization of chickpea in food production.

3. Chickpea grain nutritional components and implication on human's health

Adequate nutrition in early life is a prerequisite for human capital formation and economic development (Victora et al., 2008). The period from birth to two years of age (the first 1000 days) is the "critical window" for the promotion of optimal growth, health, and development (www.thousanddays.org). Insufficient quantities and inadequate quality of foods have a detrimental impact on health and growth in these important years. Undernourished children fail to reach their potential in cognitive development, are more likely to be below average height when they reach adulthood, to have lower educational achievement, to give birth to smaller infants and have lower economic status in adulthood, with effects that spill over to future generations (Victora et al., 2008). Although poor child-feeding practices is a problem predominantly thought to exist in low-income and middle income countries, malnutrition is rapidly rising among developed nations as well.

The consumption of adequate nutritious foods is critical not only during the developmental period of infancy, but also for maintaining good health and food security of the global population throughout life. A growing consensus is forming around the prediction that the global human population will reach nearly 10 billion people by 2050 (FAO, 2009a), and a major strain on the protein sources in the coming decades is predicted (Esnouf et al., 2011). This is due to the expected increase in world population, along with an increase in the proportion of middle class, change in consumer behavior and a decline in fish stocks. At the same time, the animal protein intake is high in industrialized countries (about 65–70% of the total protein intake). Yet the production of animal protein is more expensive regarding water and energy resources than plant-based protein. It is therefore important to rebalance the contributions between animal and plant proteins -or other alternatives-in sustainable food systems allowing access to quality protein intake to the entire world population.

In this context, utilization of the chickpea crop as an excellent source of micro and macro nutrients is mandatory in the long route to nutritional improvement.