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# Chickpea domestication in the Neolithic Levant through the nutritional perspective

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**Abstract**

An alternative approach to the process of selection and domestication of grain crops in early history based on nutritional value is proposed. Selection by a long trial and error process among a number of wild large seeded legumes gave rise to a nutritionally superior domesticated chickpea among the selected ''founder crops'' of the Neolithic Near Eastern agriculture. We found considerably higher free tryptophan levels in cultivated stocks (44 desi and 29 kabuli types from 25 countries; 1.10 mg/g seed dry weight), compared with the wild progenitor *Cicer reticulatum* (15 accessions; 0.33 mg/g seed dry weight). Dietary tryptophan determines brain serotonin synthesis, which in turn affects certain brain functions and human behaviour. We suggest that these nutritive facts may explain the decision of prehistoric farmers to choose this rare species and struggle to keep such an agronomically complicated crop under domestication.


*Keywords:* Chickpea; Legumes; Domestication; Neolithic; Nutritional

## 1. Introduction

About 11,000 years ago (before present; BP), humans domesticated several plant species in the Near East and harnessed them to their needs. Farming is thought to have originated with a group of seven grain crops (diploid einkorn wheat, tetraploid emmer wheat, barley, pea, lentil, chickpea, bitter vetch) and flax (a fibre crop), the so called ''founder crops package'' (Zohary and Hopf, 2000). Were the first farmers able to distinguish favourable nutritious plants from the wealth of species in their surroundings? The intuitive answer is probably yes, as evident from the dominant status of most of these ''founder crops'' in modern food production. Surely, storage stability and taste were major nutritive determinants in the decision making of early farmers, similarly to present day preferences. Dry chickpea seeds can be stored from season to season similarly to cereals and other legumes (e.g. wheat, barley or lentil). No perceptible taste changes occur under dry storage conditions, up to 52 weeks, and heat treatment may even improve lipid stability and thereby storage quality (Williams and Singh, 1987).

Plant domestication processes are traditionally discussed in terms of the genetic changes related to breakdown of seed dispersal and seed dormancy, seed size and other plant characters bearing on agronomic performance, both qualitative and quantitative, and on the profitability of farming operations (Abbo et al., 2003; Harlan, 1992; Ladizinsky, 1998; Zohary, 1996). However, data on the nutritional value of Near Eastern

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domesticants and its bearing on the domestication processes was rarely presented, except perhaps for the inferior protein content of domesticated tetraploid wheat relative to wild emmer wheats (Avivi, 1978).

Chickpea domestication presents an interesting case to evaluate models of crop evolution. Although the founder crops are traditionally considered as a coherent "agronomic package" (Zohary and Hopf, 2000), chickpea stands as an exception among the wild progenitors of the founder grain crops and their domesticated derivatives (Abbo et al., 2003). The distribution of most wild progenitors of the founder crops is relatively wide, extending through the Near East and West Asia, and in part into Central Asia, while the wild progenitor of chickpea, *Cicer reticulatum* Ladiz., is a rare species reported from only several locations in south-eastern Turkey (37.3–39.3°N, 38.2–43.6°E) (Ladizinsky, 1995). Seed dispersal mode of chickpea is also an exception among its companion Near Eastern grain legumes (Ladizinsky, 1980). Pod dehiscence is a typical feature of the wild progenitors of pea and lentil (Zohary and Hopf, 2000), whereas in wild *C. reticulatum* pod dehiscence is not an agronomic problem as most pods are retained intact at full maturity (Ladizinsky, 1980). The cultivation of most founder crops seems to have been relatively simple and did not require sophisticated agro-techniques. Chickpea, again an exception to this rule, was transformed into a summer crop (thereby compromising 10 to 90% of its potential grain yield as the result of water shortage, Abbo et al., 2003) probably already in Neolithic times. This transformation enabled farmers to avoid the devastating effect of Ascochyta blight caused by the fungus *Didymella rabiei* (Pass.) Lab., which may cause total crop losses in winter (Abbo et al., 2003). This required a supposedly long and quite inefficient selection for vernalization-insensitive types (Abbo et al., 2003), again an exception among the accepted models for rather rapid domestication of other Near Eastern crops (Zohary, 1996).

Why then was the rare and agronomically problematic chickpea chosen to be among the initial crop assemblage, a process mediated through the development of a novel agronomic practice, summer cropping, which may involve a considerable loss of the potential yield? In an attempt to account for the domestication of the wild *C. reticulatum* and its transformation into a summer crop we examined its nutritive value. Specifically, we determined in seeds of 88 wild and domesticated chickpea accessions the levels and nutritional quality of total protein and of the limiting essential amino acid (EAA) tryptophan, which has recognized effects on human behaviour and is known to be perceived by animals too (Ettle and Roth, 2004; Koopmans et al., 2005; Markus et al., 2005).

## 2. Materials and methods

Seeds of a wide collection of chickpea cultivars representing all major chickpea growing areas of the world (44 desi and 29 kabuli types) originating from 25 countries alongside 15 wild *C. reticulatum* accessions were employed in the chemical analyses. All the seed material used for the analyses were harvested from plants grown in replicated experiments under standard agronomic practice in the Faculty of Agriculture farm in Rehovot Israel, under similar husbandry conditions.

Free tryptophan was extracted by microwave from individual ground seeds (Kerem et al., 2005). Total tryptophan was determined in ground seeds after protein hydrolysis with 4.2 N NaOH. Tryptophan was analyzed by reversed-phase chromatography (Allred and MacDonald, 1988). The LC analyses were carried out using a Spectra HPLC system with Chromquest software (version 2.51), a pump (p4000), an autosampler (AS3000), and a diode-array detector (UV6000LP) (Thermo Separation Products, San Jose, CA, USA). The separation was carried out on a LunaII™ ODS column (250 × 4.6 mm I.D.) (Phenomenex, New York, NY, USA) with a guard column (Phenomenex C-18, 1.0 × 4.6 mm I.D.).

Crude Protein was determined in ground seeds using block digestion and Tecator Kjeltec™ Auto 2400 Analyzer – a modified Kjeldahl procedure with automatic distillation and titration (AOAC 976.06 (G) and (H)). Dry seed weight was determined after oven drying at 60 °C for 4 h (forced air).

## 3. Results

We surveyed a wide collection of chickpea cultivars (44 desi and 29 kabuli types from 25 countries), and compared their seed features with the respective features of the wild progenitor (15 accessions). The mean seed weight of the wild group does not differ from that of the desi group and both desi and wild chickpea differ from kabuli chickpea (Fig. 1, Tukey–Kramer HSD, at alpha = 0.05). Mean protein content does not differ between the wild, desi and kabuli groups (Tukey–Kramer HSD, at alpha = 0.05). In agreement with the literature we found that chickpea seeds contain 5% oil, 65% carbohydrates, and 16 to 25% proteins. The total seed protein content of the domesticated group (mean 19.41%, 18.62–20.22 (95% CL)) did not differ significantly from their

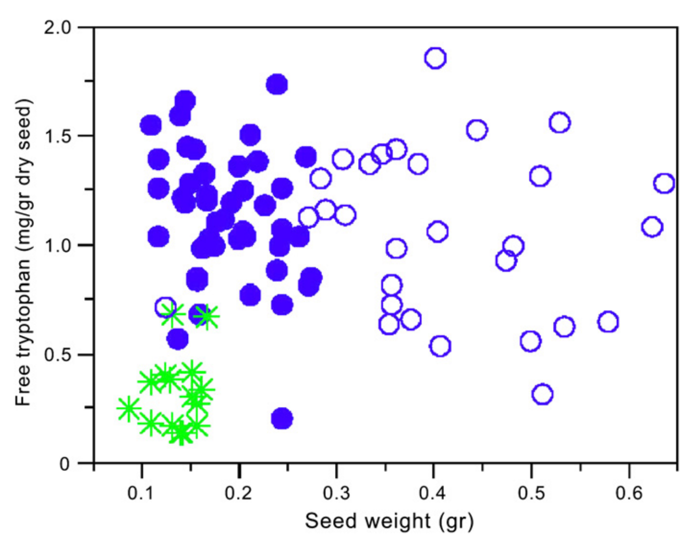


Fig. 1. The relationship between seed weight (gr) and the level of free tryptophan (mg/gr dry seed) in dry chickpea seeds (* wild *Cicer reticulatum*; ○ kabuli chickpea; ● desi chickpea).