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Effect of water cooking on proximate composition of grain in three Sicilian chickpeas (*Cicer arietinum* L.)

Giovanni Avola [a,*], Cristina Patanè [a], Riccardo N. Barbagallo [b,1]

[a] CNR – Istituto per i Sistemi Agricoli e Forestali del Mediterraneo (ISAFoM), Str.le V. Lancia, Zona Industriale, Blocco Palma I, 95121 Catania, Italy
[b] Dipartimento di Scienze delle Produzioni Agrarie e Alimentari (DISPA), Università degli Studi di Catania, Via S. Sofia 98, 95123 Catania, Italy

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ABSTRACT

The aim of this study was to assess the effects of cooking upon proximate composition in three Sicilian chickpeas differing for seed-coat incidence ('12CL2'–low, 'Calia'–medium, 'Etna'–high). Raw and cooked seeds were analyzed for moisture, nitrogen, starch, ash, fat, tannins, crude fiber, magnesium, calcium and iron content. Among cultivars, 'Etna' (higher in seed-coat incidence) exhibited the greatest tannin content in raw seeds (>6 g kg^{-1} dry weight-DW). Cooking induced a drop in tannins. Protein content did not differ with cultivar in raw seeds (238.0 g kg^{-1} DW) but increased after cooking (+6%). Starch content was strongly reduced after cooking (−30% on average), irrespective of cultivar. Fat content (43.6 g kg^{-1} DW in raw seeds) did not vary with cultivar but increased with cooking. This last determined a decrease of ash content (−31.3% in average). Minerals diminished as well due to cooking process, but with a different extent depending on cultivar; iron content decreased in all chickpeas except 'Etna', calcium and magnesium content greatly diminished in '12Cl2' and 'Calia', less in 'Etna'. The higher rate of mineral retention of 'Etna' seeds could be attributed to their higher seed coat incidence.

1. Introduction

Chickpea (*Cicer arietinum* L.) is one of the oldest and mostly consumed grain legumes in the world, after soybean, bean and pea. Its grain, widely used in the human diet, is an important source of proteins, carbohydrates and crude fiber, as well as of vitamins (primarily those of B group) and minerals, such as K, Zn, Ca and Mg.

Chickpeas are consumed, as whole or dehulled, after cooking and/or other technological processes. Cooking, which is the oldest and the best known method for making chickpeas edible, allows the inactivation of thermoinstable antinutritional compounds such as inhibitors of trypsin (Frias, Vidal-Valverde, Sotomayor, Diaz-Pollan, & Urbano, 2000), the decrease in phytic acid content (Iyer, Kadam, & Salunkhe, 1989; Khalil & Mansour, 1995; Vidal-Valverde et al., 1994) and α-galactosidase (El Adawy, 2002), and in the meanwhile confers particular sensorial traits to the product, such as color, consistence and taste, as appreciated by consumers (Avola & Patanè, 2010; Costa, Queiroz-Monici, Reis, & Oliveira, 2006; Patanè, 2006; Toledo & Canniatti-Brazaca, 2008).

Seed soaking and/or cooking may, in turn, cause considerable losses in nutrients, as hydrosoluble vitamins, due to also their thermal instability (Abdel-Hamid, 1983; El Adawy, 2002), and induce the denaturation of proteins with their leakage into liquid medium (Haytowitz & Matthews, 1983).

Although many researches have been conducted on nutritional composition of chickpea, or were addressed toward the assessment of its so called 'cooking quality' throughout many different indices such as seed weight and dimension, protein, carbohydrates and ash content, seed water absorption (Avola & Patanè, 2010; Coşkuner & Karababa, 2003; Kaur, Singh, & Sodhi, 2005; Patanè, Iacoponi, & Raccuia, 2004), not many scientific contributions exist about the grain retention of the main chemical constituents after cooking in chickpea. Indeed, several authors (Avola & Patanè, 2010; Avola, Gresta, & Abbate, 2009; Sefa-Dedah & Stanley, 1979) report that seed-coat incidence on seed weight plays a key role in chemical (e.g. presence of tannins, mainly located in the seed-coat) and technological characteristics (e.g. seed water uptake dynamism) in legumes, but references on its influence upon nutritional quality of chickpeas after cooking are still not available in literature.

To this purpose, we studied the influence of water cooking upon some chemical constituents of the grain in three genotypes of chickpea originating from Sicily (South Italy), differing for seed-coat incidence, in order to discriminate genotypes on the basis of physico-chemical and technological properties of the seed.

* Corresponding author. Tel.: +39095291681; fax: +39095292870.
E-mail addresses: giovanni.avola@cnr.it (G. Avola), cristinamaria.patane@cnr.it (C. Patanè), rbarbaga@unict.it (R.N. Barbagallo).
[1] Tel.: +390957580213; fax: +390957141960.

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2. Materials and methods

2.1. Plant material and sample preparation

Three Sicilian cultivars of kabuli chickpea with similar seed weight (0.33 g on average), but differing for seed coat incidence on the entire seed weight ('12CL2'-low, 'Calia'-in the average, 'Etna'-high in seed coat incidence) were selected for this study. The cultivars were grown in a hilly site of inland Sicily (Enna, South Italy, 37°23'N, 14°21E) during the winter season 2001–2002. In a randomized block experimental design with three replicates, seeds of chickpeas were open field sown in a 30 plants m^{-2} plant density, in plots measuring 12 m^2 (m 4 × 3) with a 0.50 m distance between rows. Seeds were harvested by hand on the first decade of July 2002. All samples were washed with tap water to remove dust and with deionized water afterward. The seed samples were dried to original dryness, then half of them was kept for cooking experiments, the remaining was ground in a laboratory micro-mill to pass a 1 mm sieve (model MF10, IKA Group, Staufen, Germany) and stored at room temperature for further chemical analysis. These last were performed at the end of July 2002.

2.2. Physical characteristics

Seed coat incidence (SCI, %) on the entire seed weight was determined gravimetrically in raw seeds only. Ten seeds were soaked in distilled water for 12 h at room temperature (18–20 °C), to facilitate the seed coat removal, then the two fractions (seed coat and cotyledons) were separately dried at 65 °C in a ventilated oven until constant weight.

The electric conductivity (EC) of the cooking water was also measured in a portable conductivity meter (Mod. CyberScan CON 400/410, Eutech Instruments, Pte Ltd, Nijkerk, The Netherlands).

Triplicate determinations of all samples were performed for the parameters studied. Results were expressed on a dry weight (DW) basis.

2.3. Cooking process

Fifty seeds for each replicate were placed into a 1 L beaker containing boiling distilled water at a 1:7 ratio (seed:water, w/w) and submitted to cooking process. The seeds were considered cooked after a predetermined cooking time. The optimum cooking time for each cultivar was assigned in previous tests, when the 80% of the seeds became sufficiently tender (approximately at a 15 N cm^{-2} firmness) (Avola & Patanè, 2010; Clemente, Sanchez-Vioque, Vioque, Bautista, & Millan, 1998). The cooking time was determined as the average of triplicate determinations. Seed texture of cooked chickpea samples was tested by a texture meter (Mod. FT 011; Bertuzzi, Brugherio, Italy) equipped with a 60 mm-diameter conical plunger. To better compare raw and cooked seeds in proximate analysis, these last were drained then oven-dried at 65 °C until seed moisture content reached that measured before cooking (approximately 8 g 100 g^{-1}). After determining the moisture content, the cooked seeds were ground and stored at room temperature in plastic containers at room temperature until analysis.

2.4. Proximate composition

Each meal sample from raw or cooked grains was analyzed for moisture, tannins, nitrogen, ash, fat, crude fiber, starch, iron, magnesium and calcium contents, according to AOAC methods (2000). Moisture content was determined oven drying a meal sample at 65 °C until constant weight; nitrogen content was determined according to the Kjeldahl procedure, and the factor N 5.7 was used to convert nitrogen into crude protein, following what reported by Mosse (1990) for grain legumes; starch content was determined as reducing sugars after complete acid hydrolysis with the Fehling method; fat content was determined gravimetrically by the Soxhlet method; ash content was determined by using AOAC Method #940.26 and crude fiber by Method #978.10; iron, magnesium and calcium content were analyzed spectrophotometrically (spectrophotometer HACH DR⁄2010; HACH Co., Loveland, CO, USA) after ashing, by following the procedures as described in HACH (1996). Samples for the determination of mineral content were also prepared after ashing by using a nitric acid–sulfuric acid–perchloric acid mixture 20:4:1 (v/v) according to Singh, Subrahmanyam, and Kumar (1991) and were analyzed for calcium (Ca), iron (Fe) and magnesium (Mg) content using a colorimetric spectrophotometer (HACH DR/2010, HACH Co., Loveland, CO, USA). To this purpose, 5 g of the samples dissolved in 100 mL of bidistilled water was used, and minerals were determined by following the procedures described in HACH (1996). In particular, for the Fe, the FerroZine reagent was adopted and Fe content, given as 1 mg L^{-1} of total Fe, was read at a wavelength (λ) of 510 nm; for calcium and magnesium content (expressed as $CaCO_3$ and $MgCO_3$, respectively), the Calmagite Colorimetric method was adopted and their content was read at λ 522 nm. Tannins were also quantified with a colorimetric spectrophotometer (HACH DR/2010, l 700 nm), after their extraction according to Burns (1971), adopting as standard a mixture of 19.5 mL distilled water, 0.5 mL TanniVer 3 reagent and 5 mL Na_2CO_3 solution (HACH, 1996).

The retention of the chemical and nutritional constituents of the seed after the cooking process was calculated as follow: retention (%) = (a/b)*100, where a is the content after cooking and b is the content before cooking.

2.5. Statistical analysis

All data were subjected to analysis of variance (ANOVA) and the Tukey's honest significance test (HSD) was performed to identify the pairs of means that are significantly different.

3. Results and discussion

Seed coat incidence, measured before the cooking process, well discriminated the genotypes: '12CL2' showed the lowest value (4.7%), 'Etna' the highest (5.7%) (Fig. 1).

The latter also exhibited the greatest amounts of tannins in seed coat (>6 g kg^{-1} DW) (Table 1). Accordingly to literature (Wang,

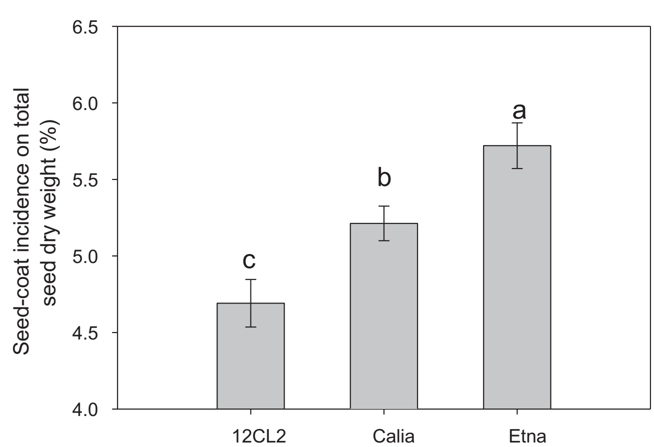

Fig. 1. Seed-coat incidence (%) on total seed dry weight in three Sicilian cultivars of chickpea (number of replications: 3).

Table 1
Proximate composition in raw and cooked seeds in three Sicilian cultivars of chickpea.

Cultivar	Tannins		Crude protein		Starch		Crude fiber		Fat		Ash		Fe		Ca		Mg	
	Raw	Cooked	Raw	Cooked	Raw	Cooked	Raw	Cooked	Raw	Cooked	Raw	Cooked	Raw	Cooked	Raw	Cooked	Raw	Cooked
	g kg^{-1} dry weight												mg kg^{-1} dry weight					
12CL2	3.23	0.27	239.6	251.2	439.6	316.6	33.3	33.4	44.1	62.0	39.3	28.2	34.3	23.4	1102.2	212.7	1560.9	283.4
Calia	2.91	0.14	236	236.2	475.0	305.8	35.7	32.6	39.8	65.1	37.1	24.4	29.5	22.6	830.2	179.4	1224.5	315.4
Etna	6.18	0.16	238.3	256.9	442.8	287.6	34.4	38.0	47.1	60.5	33.9	23.2	26.3	26.1	739.3	328.2	1080.6	344.1
Average	*4.11*	*0.19*	*238*	*248.1*	*452.4*	*303.3*	*34.5*	*34.6*	*43.6*	*62.5*	*36.7*	*25.3*	*30.1*	*24.0*	*890.6*	*240.1*	*1288.7*	*314.3*
ANOVA																		
Cultivar	0.48***		n.s.		n.s.		n.s.		n.s.		2.08*		2.18*		71.0**		148.2*	
Cooking	0.39***		9.97*		24.3***		n.s.		4.14***		1.70***		1.78***		58.0***		121.0***	
CxC	0.71***		n.s.		n.s.		n.s.		n.s.		n.s.		3.08***		91.2***		206.4***	

Tukey's Honestly Significant Difference (HSD) test, $^{*}P < 0.05$, $^{**}P < 0.01$ and $^{***}P < 0.001$.
Number of replications: 3.

Hatcher, Tyler, Toews, & Gawalko, 2010), the thermal treatment by cooking induced a strong decrease in tannin content: the retention of these phenolic compounds was less than 5%, with no significant difference within cultivars. This decrease may be attributed to a change in their chemical structure (Satwadhar, Kadam, & Salunkhe, 1981) or/and to their leaching into the cooking water (Vijayakumari, Siddhuraju, Pugalenthi, & Janardhanan, 1998).

Crude protein content did not differ with cultivar before cooking (238.0 g kg^{-1} DW, on average). Cooking resulted in a slight but significant increase in crude proteins (+6%), probably due to a loss of soluble solids during process, which would increase the concentration of protein (Wang et al., 2010).

Cooking process significantly reduced the starch content by 30% in all cultivars. This reduction may be due to its gelatinization and solubilization, or to an inactivation of amylase inhibitors during cooking (Wang et al., 2010).

Crude fiber content did not differ with cultivar and was not affected by cooking (approx. 35 g kg^{-1} DW). This is in contrast with several authors (Alajaji & El-Adawy, 2006; Shah et al., 2011; Wang et al., 2010), who reported a fiber increase in chickpea after cooking, which could be attributed to a protein fiber complex formed after possible chemical modification induced by cooking of dry seeds (Bressani, 1993).

The lipid content in raw chickpea was found to be 43.6 g kg^{-1} DW. Fat did not change with genotype, but significantly increased after cooking by a percentage ranging between +30% (Etna) and +62% (Calia). An increase of fat content in chickpea after cooking, although to a lesser extent (+6%), was previously reported by Shah et al. (2011), while Alajaji and El-Adawy (2006) found instead a decrease after thermal process.

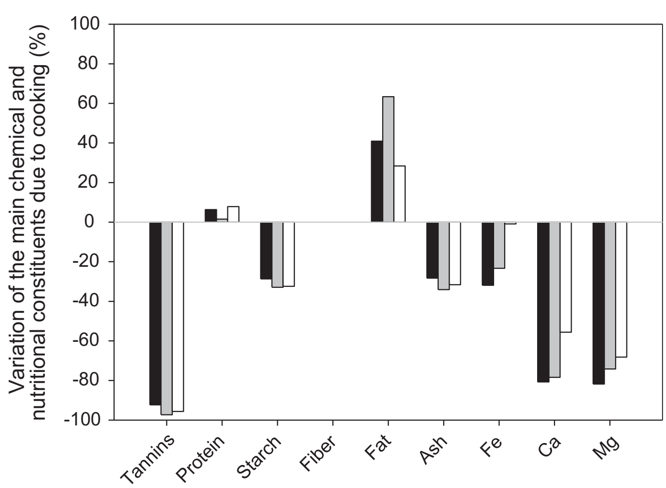

Fig. 2. Variation percentage after cooking for the main chemical and nutritional constituents in three Sicilian chickpea (■ 12CL2 ■ Etna □ Calia).

Ash content differed with cultivars in raw materials, with '12CL2' exhibiting the highest content (39.3 g kg^{-1} DW) and 'Etna' the lowest one (33.9 g kg^{-1} DW) (Table 1). Cooking determined significant losses of ash (−31.3% on average), with no differences among genotypes after process, mainly due to the ash leakage into the cooking water.

Iron content significantly varied with cultivar in raw seeds: '12CL2' had the highest value (34.3 ppm), 'Etna' the lowest (26.3 ppm). Minerals leached from the chickpea seeds into the boiling water during cooking, in a different extent depending on cultivar (Fig. 2). Cooking significantly reduced the levels of iron except in 'Etna', where iron retention was almost full (99.1%). Presence of a significant amount of iron ions in cooking water showed the leakage of the iron complexes from chickpea into hot water (Haytowitz & Matthews, 1983; Shah et al., 2011). However, cooking process has been proved to be beneficial for human health since it involves a significant improvement in availability of Fe, which may be due to leaching out of antinutrients (Kakker, 1992; Khalil & Mansour, 1995).

Cooking treatment significantly reduced the levels of calcium by 78%, 80% and 55% and the level of magnesium by 82%, 74% and 68%, for '12CL2', 'Calia' and 'Etna', respectively. The higher rate of mineral retention of 'Etna' seeds could be attributed to their higher seed coat incidence.

Electric conductivity of coking water was 3.49, 3.76 and 4.11 mS cm^{-1} in 'Etna', '12CL2' and 'Calia', respectively. This parameter, which supports the results of the present study, could be considered as an index of the leaching rate of all chemical compounds of the seeds into the water during cooking process.

4. Conclusions

Cooking involved an overall variation in nutritional value of chickpeas, mainly as a consequence of almost total loss in tannins from seeds. However, cooking affected the composition of chickpea to a different extent, depending on cultivar. Chickpea with the highest seed coat incidence exhibited a reduced rate in minerals losses. Indeed, although a thicker seed coat incidence negatively affects the technological quality of the seeds (Avola & Patanè, 2010), conversely it may contribute to the retention of minerals, such as iron, calcium and magnesium, as observed in the present study.

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