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Variation in seed and pod characteristics in relation to cooking time among valencia groundnut, *Arachis hypogaea* L. germplasm

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Abstract

The freshly harvested in-shell groundnut (*Arachis hypogaea* L.) and groundnut seeds boiled in brine are consumed as snacks in many parts of the world. Groundnuts with 3-4 seeded pods, large-seeds, low cooking time (CT), low oil and high protein contents, and sweet taste are preferred for boiling uses. Thirty-three valencia germplasm lines were grown during the 1995 rainy and 1995/96 postrainy seasons at ICRISAT Center, Patancheru, India. Fresh- and cured-pods and seeds of each genotype were evaluated for physicochemical traits and CT. The CT of untreated (without pre-soaking) and pre-soaked (water or 1% brine) seeds and pods were compared. The pre-soaked treatments resulted in significant reduction in CT. The reduction in CT was greater in brine-soaked seeds and pods than that of in water-soaked seeds and pods. Growing season had significant influence on CT. For fresh-seed boiling, the produce of postrainy season and for cured-seed boiling, the produce of rainy season was preferable. There was no consistency in association of CT with seed traits. It changed with treatments of seeds. ICG# 326, 1307, 2148, and 6224 were the most preferred genotypes identified for boiling uses. These can be used in a breeding program to develop better boiling type groundnuts.

Key words: Peanut (*Arachis hypogaea*), cooking time, boiled groundnut, germplasm

Introduction

Groundnut (*Arachis hypogaea* L.) is the world's fifth most important source of edible oil and vegetable protein. It contain 44 to 56% oil and 22 to 30% protein on a dry seed basis and is a rich source of minerals (phosphorus, calcium, magnesium, and potassium) and vitamins (E, K, and B group) (Savage and Keenan, 1994). Oleic, linolic, and palmitic acids together account for over 80% of the total fat in groundnut oil (Dwivedi *et al.*, 1993). Sucrose accounts for 90% of the total carbohydrates among different botanical types in groundnut (Pattee *et al.*, 2000). About two thirds of the world groundnut production is crushed for high quality edible oil and the remainder is consumed as human food in various forms. Over the last three decades, there has been a gradual shift away from oil and meals into confectionery use, with major increase in Asia, Latin America, and the Caribbean countries than in Africa (Freeman *et al.*, 1999). The food uses of groundnut include (i) peanut butter, (ii) roasted shelled nuts, (iii) in-shell roasted nuts, (iv) in-shell boiled nuts, (v) confections and candies, and (vi) groundnut-based fortified foods.

The freshly harvested in-shell groundnut and groundnut seeds boiled in brine are consumed as snack in many parts of the world. Genotypes with a greater proportion of 4- and 3-seeded pods, large-seeds, low cooking time, low oil, high protein, and sweet taste are preferred for boiling. Groundnut genotypes belonging to the valencia group (subsp. *fastigiata* var. *fastigiata*) have higher proportion of 3- and 4-seeded pods, and seeds are sweater in taste than other botanical groups. Not much is known about seed and pod traits preferred in boiling use, their interaction with each other, and the genetic variation available for them.

Duration of cooking time affects the seed composition of groundnut. Long duration causes a reduction in soluble carbohydrates, soluble protein, and free amino acids, but total protein, insoluble carbohydrates, and oil remain unaffected. While the total seed protein content remains unaffected during boiling, the protein and polypeptide compositions are greatly altered (Murugesu and Basha, 1989). The duration of cooking and cooling time also affects the salt concentration of frozen boiled valencia groundnut (Ammerman *et al.*, 1971). Heating temperature has a highly significant effect on the flavor scores of peanut paste. Samples heated in water at higher temperatures had less of the flavor usually associated with raw, wet groundnuts and were not as 'harsh' or 'bitter' as those heated at lower temperatures (McWatters and Heaton, 1974). Seed weight and volume, swelling index, and hydration capacity were positively correlated with cooking time in chickpeas (Williams *et al.*, 1983). Cooking time was negatively correlated with soluble sugar and positively correlated with protein content of dry legumes (Akinyele *et al.*, 1986).

The present experiment was carried out to study variation in 33 valencia groundnut germplasm lines for seed and pod characteristics in relation to cooking time, and to identify genotypes with desirable traits for boiling uses.

Materials and methods

Thirty-three valencia germplasm lines including control cultivar Gangapuri were grown unreplicated under high input (4.2 kg P/ha as basal, 400 kg Gypsum/ha at peak flowering, irrigation, and protection against insect pests and foliar diseases) conditions during the 1995 rainy and 1995/96 postrainy seasons at ICRISAT Center, Patancheru, India. They were individually bulk harvested at maturity in each season and the bulk pod samples were brought to laboratory for cleaning and storage. The cleaned fresh- pods and-seeds, and cured-pods and-seeds (pods sun dried to seed moisture content of about 8%) bulks, each divided into nine samples, were stored in a cold room at 5° C. The nine samples, which served as experimental units corresponding to each pod/seed treatment, were randomly allocated to three soaking treatments, untreated (without effecting pre-soaking), pre-soaking (16 h) of pods and seeds in distilled water, and pre-soaking (16 h) of pods and seeds in brine (1% saline), each treatment receiving three samples. Observations on optimum cooking time of seeds and pods of each genotype under three soaking treatments, fresh- and cured-pod weight; seed weight, seed volume, and seed density of the cured-seed; and hydration and swelling capacity of the pre-soaked (in water and brine) fresh- and cured-pods and-seeds were recorded as follows.

Cooking time (CT): For determination of CT of seed, a block digestor (Model 20 DB, Tecator, Sweden) was used to maintain uniform and constant temperature. Twenty-five mature seeds of uniform size were placed in a 250 ml glass digestion tube containing 100 ml of boiling distilled water. For determining CT of pod, 10 mature pods of uniform size were placed in 100 ml boiling water in a 250 ml glass beaker covered with watch glass on a sand bath. Boiling in both cases continued until the desired softness of the seed, as determined by pressure of the fingers, was realized. The time taken (in min) to achieve the desired softness in the seed was recorded as the CT of the sample (seed or pod).

Pod weight (PW) and seed weight (SW): Randomly selected ten mature pods or 25 mature seeds were weighed (in g).

Hydration capacity (HC): Twenty-five seeds or ten pods were transferred to a 250 ml beaker containing 100 ml water or brine and left at room temperature for 16 h. The hydrated seeds or pods were taken out and the water on pods or seeds surface was removed by absorbent paper. These pods or seeds were reweighed to determine HC;

HC/seed = (Weight of sample after soaking – weight of sample before soaking)/ # seed

HC/pod = (Weight of sample after soaking – weight of sample before soaking)/ # pod

Seed volume (SV): Twenty-five mature seeds were placed in a 100 ml measuring jar containing 30 ml of water and the increase in volume was recorded as the volume of the seeds (in ml).

Seed density (SD): It was calculated as the ratio of seed weight to seed volume in g/ml.

Swelling capacity (SC): The soaked seeds obtained from HC observation were placed in a 100 ml measuring cylinder containing 40 ml distilled water and the increase in volume was determined to calculate SC;

SC/seed = (volume of the sample after soaking – volume of the sample before soaking)/ # seed

The observations on shelling and chemical characteristics of each genotype were recorded as follows.

Shelling characteristics: A random sample of 500 g mature cured pods of each genotype was taken to record pod and seed characteristics. For seeds per pod, the bulk pod sample was separated into 4-, 3-, 2- and 1-seeded pods. The proportion for each category of pods was determined and seeds per pod was expressed based on the descending order of their proportions of different number of seeds per pod for a given genotype. Later on, same pod sample was shelled to determine the shelling outturn. From the shelled seeds, 100-mature seeds were randomly selected and weighed for seed mass (in g).

Chemical characteristics: Bulk sample of untreated (without pre-soaking) sound mature cured-seeds of each genotype was analysed for oil and protein contents and fatty acid composition. Oil content was determined using Nuclear Magnetic Resonance Spectrometry (Jambunathan *et al.*, 1985). For estimating protein content, nitrogen content was determined by Technicon auto analyzer (Singh and Jambunathan, 1980) and a factor of 5.46 was used to convert nitrogen into crude protein content. Fatty acid methyl esters (FAME) of triglycerides were prepared (Hovis *et al.*, 1979) and analysed to estimate individual fatty acid contents (Dwivedi *et al.*, 1993). From the fatty acid estimates, the following seed quality characteristics were determined (Mozingo *et al.*, 1988) : (i) oleic (O)/linolenic (L) acid ratio = % oleic acid/% linolenic acid; (ii) polyunsaturated (P)/saturated (S) acid ratio = % linolenic acid/total saturated fat (TSF), where TSF = % palmitic acid + % stearic acid + % arachidic acid + % behenic acid + % lingnoceric acid.

Statistical analysis for PW, SW, SV, SD, HC, and CT was carried out following a multi-factor completely randomized design analysis of variance. Simple correlations among these traits were determined. No statistical analysis was carried out for shelling and chemical characteristics as they were based on single determination.

Results and discussion

Variation in PW, HC, and CT of fresh- and cured-pod

Pod boiled in water without pre-soaking: The genotypic differences in PW and CT of the fresh-and cured-pod were significant (P<0.01). Their range and mean are presented in Table-1. The average fresh PW was significantly greater than cured PW because of higher moisture content in seed and shell in the former. No genotype recorded significantly greater fresh PW than control Gangapuri (49 g). However, ICGs 43, 288, 2738, 3195 and 6479 had significantly lower fresh PW (35-39 g) than Gangapuri. None of the genotypes showed significantly greater or lower cured PW than Gangapuri (31 g). This indicated that genotypes had varying moisture content in pod at the time of harvest. However, after curing the difference in moisture content disappeared and cured PW became similar. The average CT of cured-pods was 6 times more than that of fresh-pods (34 min). The CT of fresh-pod in all genotypes including Gangagpuri (34 min) did not differ significantly with each other. The differing moisture content of fresh-pod of genotypes did not have any influence on their CT. While ICGs 319, 355, and 1961 recorded significantly lower CT for the cured-pods (180-187 min), the remaining genotypes did not differ significantly from Gangapuri (205 min).

Pod pre-soaked prior to boiling: The differences for HC and CT between fresh- and cured-pods, and pre-soaking treatments (water and brine), and among genotypes were significant (P<0.05-0.01).

The range and mean for HC and CT of the pre-soaked fresh- and cured-pods of 33 genotypes are also presented in Table-1. The HC (g/seed) of cured-pods was more than 2.5 times greater than that of fresh-pods in both pre-soaking treatments, primarily because of the initial higher moisture content in the latter. The HC of fresh-pods was similar in both water and brine. The same was also true for cured-pods. The HC of water soaked-fresh pods of test genotypes was similar to that of Gangapuri; but for cured-pods, it was, in case of ICG 1384 (1.04 g/seed), ICG 6224 (0.74 g/ seed), and ICGs 1307 and 6479 (0.73 g/seed each), significantly greater than Gangapuri (0.62 g/ seed). The HC of brine soaked-cured-pods of ICGs 42, 288, 1611, and 30 was significantly lower (0.44-0.45 g/seed) and that of ICG 6224 (0.78 g/seed) significantly greater than that of Gangapuri (0.64 g/seed). The average CT of brine-soaked fresh- and cured-pods was significantly lower than that of the water-soaked fresh- and cured-pods. The average reduction in CT of brine-soaked pod was 3 min for fresh-pods and 7 min for cured-pods. Genotypic differences in CT of water- and brine-soaked fresh-pods were nonsignificant. The CT of water-soaked cured-pods of 29 genotypes (112-127 min) and of brine- soaked cured-pods of 9 genotypes (105-112 min) was significantly lower than Gangapuri (135 min for water-soaked and 120 min for brine-soaked cured-pods). ICGs 42, 319, 326, 355, 1384, 1830, 2148, and 3195 were common in both soaking treatments. ICGs 319 and 326 in water-soaked (111.7 min) and ICG 2148 in brine-soaked (105.0 min) treatments had the lowest CT. These three genotypes also had the lower CT than Gangapuri for cured-pods without pre-soaking treatment.

Table 1 Range and mean of 33 groundnut genotypes for pod weight (PW) and cooking time (CT) of fresh and cured pods boiled in water and for hydration capacity (HC) and CT those soaked for 16 h in water and brine prior to boiling, 1995 rainy season

Pod type		Fresh and cured pods boiled in water			
		PW (g)		CT (min)	
		Range	Mean	Range	Mean
Fresh-pod		35-55	46	32-38	34
Cured-pod		24-37	30	180-217	203
SEm±			0.5		1.1
Pre-soaking	Pod type	Fresh and cured pods soaked for 16 hr in water and brine prior to boiling			
		HC (g/pod)		CT (min)	
		Range	Mean	Range	Mean
Water	Fresh pod	0.16-0.34	0.25	26-32	29
	Cured pod	0.46-1.04	0.63	112-137	123
Brine	Fresh pod	0.14-0.31	0.22	23-29	26
	Cured pod	0.44-0.78	0.61	105-123	116
SEm±			0.009		0.6

Variation in SW, SV, SD, HC, SC, and CT of the fresh- and cured-seed

Seed boiled in water without pre-soaking: Differences between seasons (except for SD), and seed curing, and among genotypes were significant (P<0.05-0.01) for SW, SV, SD, and CT. Season x seed curing (except for SD), season x genotype, seed curing x genotype interactions were also significant (P<0.05-0.01) for these characteristics. Season x seed curing x genotype interaction effect was significant only for SV (P<0.05) and CT (P<0.01).

The post-rainy season produce recorded greater mean SW (fresh-seed 17.1 g in post-rainy and 12.2 g in rainy and cured-seed 10.4 g in post-rainy and 7.2±0.09 g in rainy seasons) and SV (fresh-seed 18.2 ml in post-rainy and 13.1 ml in rainy and cured-seed 10.6 ml in post-rainy and 7.4±0.10 ml in rainy seasons) than rainy season. Season had no effect on average SD of fresh- and cured-seeds. The average CT of post-rainy season cured-seeds was significantly greater (85 min) than that of the rainy season cured-seeds (62±0.26 min). The average CT of rainy season fresh-seeds, on the contrary, was significantly greater (22 min) than that of the post-rainy season fresh-seeds (17±0.26 min).

The range and mean of 33 genotypes for SW, SV, SD, and CT of the fresh- and cured-seeds are presented in Table-2. The average SW and SV of fresh seeds were significantly greater than those of the cured-seeds. The reverse was observed for SD and CT. The average CT of cured-seeds was 3.86 times greater than that of the fresh-seeds (19 min). ICG 6224, USA 857, and ICGs 3195 and 1929 for SW (15.7-18.1 g), ICGs 1693 and 6224 for SV (17.3-19.4 ml), and ICG 1929 for SD (0.99 g/ml) recorded significantly greater values than Gangapuri (SW 14.6 g, SV 15.9 ml, and SD 0.91 g/ml) for fresh-seeds. The CT differences of fresh-seeds of genotypes were nonsignificant. For cured-seeds, no genotype recorded significantly greater SW and SV than Ganagapuri (SW 9.3 g, and SV 9.9 ml). The SD of cured-seeds of ICGs 1307, 1672, and 1693 was significantly greater (1.03-1.08 g/ml) than Gangapuri (0.95 g/ml). Except for ICG 408, which had significantly lower CT and ICGs 58 and 1757 which had similar CT as that of Gangapuri (64 min), all other genotypes showed significantly greater CT (68-87 min) than the latter for cured-seeds. USA 857 took longest time to cook.

Seed pre-soaked prior to boiling: The differences between seed curing and pre-soaking treatments, and seasons, and among genotypes were significant (P<0.1) for HC, SC, and CT. Genotype x seed curing, genotype x season, and seed curing x season effects were also significant (P<0.05-0.01) for these traits. Several other interactions were also significant (P<0.01) for CT.

Effect of seasons was significant for seed HC, SC, and CT. The HC and SC of postrainy season pre-soaked fresh- and cured-seeds were significantly greater than those of the rainy season. The CT of rainy season pre-soaked fresh- and cured-seeds, on the contrary, was significantly greater than that of the postrainy season.

The average HC, SC, and CT were significantly reduced in brine soaked compared to water-soaked fresh- and cured-seeds (Table-3). The % reduction in HC and SC was greater in fresh- seeds than in cured-seeds. On the contrary, the % reduction in CT was greater in cured-seeds than in fresh-seeds.

Table 2 **Range and mean of 33 groundnut genotypes for seed weight (SW), seed volume (SV), seed density (SD) and cooking time (CT) of fresh and cured seeds boiled in water, 1995 rainy and 1995/96 post-rainy season**

Seed type	SW (g)		SV (ml)	
	Range	Mean	Range	Mean
Fresh seed	12.0 - 18.0	14.6	12.7 - 19.4	15.6
Cured seed	5.8 - 10.3	8.8	6.3 - 10.4	9.0
SEm ±		0.06		0.07
Seed type	**SD (g/ml)**		**CT (min)**	
	Range	Mean	Range	Mean
Fresh seed	0.90 - 0.99	0.94	17-21	19
Cured seed	0.92 - 1.08	0.97	61-87	74
SEm±		0.003		0.2

Table 3 **Range and mean of 33 groundnut genotypes for hydration capacity (HC), selling capacity (SC) and cooking time (CT) of fresh and cured seeds soaked for 16 h in water and brine prior to boiling, 1995 rainy and 1995/96 post-rainy seasons**

Pre-soaking	Seed type	HC (g/seed)		SC (ml/seed)		CT (min)	
		Range	Mean	Range	Mean	Range	Mean
Water	Fresh-seed	0.02-0.09	0.05	0.02-0.08	0.05	19-26	21.8
	Cured-seed	0.25-0.34	0.28	0.20-0.35	0.27	18-22	36.9
Brine	Fresh-seed	0.02-0.05	0.03	0.02-0.07	0.04	29-42	19.4
	Cured-seed	0.22-0.33	0.26	0.21-0.34	0.26	23-35	28.7
SEm±			0.003		0.002		0.13

The water-soaked fresh-seeds of ICG 30 and both, water- and brine-soaked cured-seeds, of ICG 6224 showed significantly greater HC (g/seed) than similarly pre-soaked seeds of Gangapuri (water soaked fresh-seed 0.042 g/seed, water soaked cured-seeds 0.284 g/seed, and brine soaked cured-seeds 0.265 g/seed). ICGs 2148, 3114, 3195, 6224, 6479, 1961, and 7223 in water soaked fresh-seeds, ICG 6224 in water soaked cured-seeds, ICG 2148 in brine soaked fresh-seeds, and ICGs 326, 1929, 3114, and 6224, and USA 857 in brine soaked cured-seeds showed significantly greater SC (ml/seed) than Gangapuri (water soaked fresh-seeds 0.027ml/seed, water soaked cured-seeds 0.287 ml/seed, brine soaked fresh-seeds 0.040 ml/seed, and brine soaked cured-seeds 0.243 ml/seed). ICGs 42 and 58 in water soaked fresh-seeds, ICG 1307 in water soaked cured-seeds, and ICGs 30, 43, 58, 288, 326, 1307, 1377, 1384, 1611, 1672, 1693, 1830, and 2148 in brine soaked fresh-seeds had significantly lower CT than Gangapuri (water soaked fresh-seeds 21.8 min, water soaked cured-seeds 32.7 min, brine soaked fresh-seeds 21.2min, and brine soaked cured-seeds 22.5 min). Several genotypes which had lower than or similar CT as Gangapuri, in both water and brine soaked seeds, had higher CT than Gangapuri on curing. ICGs 42, 1307, 1693 and 355 had lowest CT under different treatments.

Variation in shelling and chemical characteristics

The genotypes differed in seeds per pod, shelling outturn, 100-seed weight, and seed color. All the genotypes, except for ICGs 30, 42, 43, and 319, were grouped into either 4-3-2-1 or 3-4-2-1 seeded pods, a trait very much preferred for in-shell boiled groundnut uses. ICGs 30, 288, 335, 326, 409, 1611, 1693, 2148, 3114, 3195, 3217, 6224, and 7223, and USA 857 recorded 70-73% shelling outturn compared with 68% of Gangapuri. Of these, ICGs 30, 409, and 6224 had also higher 100-seed weight (50-55 g) than Gangapuri (42 g). Except for ICGs 319 and 1693 with tan color seeds, the other genotypes were red seeded. Both red and tan color seeded groundnuts are acceptable for edible purpose.

The untreated (without pre-soaking) fresh- and cured-seeds were boiled and eaten to determine their taste. Genotypes identified with sweet taste for both fresh- and cured-seeds were ICGs 30, 1377, 1830, 3117, 6479, and 7223.

ICGs 1377, 1612, and 1757 had relatively low oil (450-460 g/kg dry seeds) and high protein (290 g/kg dry seeds) contents. All the genotypes showed a lower O/L ratio (0.88-1.02) indicating their shorter shelf-life (Branch *et al.*, 1990; James and Young, 1983), but had better nutritional quality because of their higher P/S ratio (1.61-1.96) (Mozingo *et al.*, 1988).

Relationship of seed and pod characteristics with CT

Fresh PW (without pre-soaking) was not correlated with CT but cured PW (without pre-soaking) was correlated with CT (r = 0.45**). While pre-soaked fresh PW was negatively correlated with CT (r = -0.27** for water- and –0.34** for brine-soaked fresh-pods), no such relationship was observed in pre-soaked cured-pods.

Correlations among SW, SV, SD, HC, SC, and CT of the untreated (without pre-soaking) and pre-soaked fresh- and cured-seeds are presented in Table-4. For both fresh- and cured-seeds without pre-soaking, SW, SV, SD, and CT (except for SV with CT for fresh-seed) were significantly positively correlated with each other. SW and SV were strongly correlated. In comparison with fresh-seeds, a stronger correlation was observed between SW and SD and SW and CT in cured-seeds. The reverse happened in the case of association between SV and SD and SV and CT. The positive relationship of CT with HC and SC in water-soaked fresh-seeds reversed to negative in brine-soaked fresh-seeds. HC and SC were positively correlated with each other both in water- and brine-soaked cured-seeds. The positive correlation of SC with CT in brine-soaked cured-seeds was not maintained in water-soaked cured-seeds.

Table 4 Correlation of seed weight (SW), seed volume (SV), seed density (SD), hydration capacity (HC), swelling capacity (SC) and cooking time (CT) of fresh and cured seeds of groundnut boiled in water and those soaked for 16 h in water and brine prior to boiling

Treatment	Character	SW	SV	SD	CT
Fresh and cured seeds# (without pre-soaking)	SW	-	0.97**	0.35**	0.13*
	SV	0.96**	-	0.11*	0.09
	CT	0.47**	0.50**	0.19**	-
		HC	SC	CT	
Pre-soaked fresh seed##	HC	-	0.19**	0.25**	
	SC	0.09	-	0.47**	
	CT	-0.11**	-0.21**	-	
Pre-soaked cured seed###	HC	-	0.84**	0.08	
	SC	0.85**	-	0.06	
	CT	0.08	0.40**	-	

above diagonal = fresh-seeds boiled in water and below diagonal = cured seeds boiled in water
Above diagonal = fresh seeds soaked for 16 h in water and below diagonal = fresh seeds soaked for 16 h in brine prior to boiling
Above diagonal = cured seeds soaked for 16 h in water and below diagonal = cured seeds soaked for 16 h in brine prior to boiling
*, ** P<0.05 and 0.01, respectively

Discussion

Very little information is available in literature on seed and pod traits preferred in boiling-type groundnuts. In addition to taste and flavor, CT is the most important consideration in selection of genotypes for boiling uses. Greater CT adds directly to the cost of processing. From the results obtained from this study, it is clear that cured-pods take much longer (6 times) than fresh-pods to cook. However, genotypic differences do occur in CT for cured-pods. Cured-pods of ICGs 319, 355, and 1961 took lesser CT than other genotypes included in the study. In case of fresh- pods, there was no difference in CT among genotypes.

In the case of pre-soaking, the treatment with brine is beneficial over water in lowering the CT for both fresh- and cured-pods. Similar results were obtained with black beans (*Phaseolus vulgaris*) when presoaked in Na salt solutions prior to cooking due to bean softening. The bean softening was caused by replacement of ions which stabilize the structure of the intercellular cement by Na ions through ion exchange or their removal by chelatin (Varriano-Marston and Omana, 1979) Genotypic differences for fresh-pod CT, under both water and brine pre-soaking treatments, were nonsignificant. But for cured-pods, ICGs 319 and 326 under water and ICG 2148 under brine pre-soaking treatment, had the lowest CT. As expected, the HC of cured- pods was greater than fresh-pods under both pre-soaking treatments because of the higher initial moisture content in the latter. The pre-soaking treatments did not have significant influence on HC of fresh- and cured-pods. Genotypic differences in HC of water-soaked fresh-pods were nonsignificant. But ICGs 1384, 6224, 1307, and 6479 had significantly greater HC than Gangapuri for water soaked cured-pods. ICG 6224 also had significantly greater HC than Gangapuri for brine soaked cured-pods.

Like cured-pods, cured-seeds also took longer time (3.9 times) than fresh-seeds to cook. Genotypic differences in CT for fresh-seeds were non-significant. But for cured-seeds, ICG 408 had CT lower than and ICGs 58 and 1757 similar to that of Gangapuri. All other genotypes had significantly greater cured-seed CT than Gangapuri. The average SW and SV were greater in fresh-seeds than in cured-seeds mainly due to higher initial moisture content in the former. The reverse was true for SD. ICG 6224 had SW and SV, ICG 1929 SW and SD, USA 857 and ICG 3195 SW, and ICG 1693 SV for fresh-seeds greater than Gangapuri. For cured-seeds, no genotype was superior to Gangapuri for SW and SV. ICGs 1307, 1672, and 1693 had greater cured-seeds SD than that of Gangapuri.

Like pods, soaking of fresh- and cured-seeds in brine reduced CT over soaking in water. ICGs 42, 1307, 1693, and 355 had the lowest CT under different treatments.

Several other genotypes, which had CT lower than or similar to as Gangapuri in the fresh-seeds under both water and brine soakings, had higher CT than the latter on curing. Although soaking in brine reduced CT, it also reduced HC and SC for both fresh- and cured-seeds. Dry beans, soaked in salt solution, absorbed less water than when soaked in water (Del Valle *et al.*, 1992) probably because of the decrease of osmotic pressure gradient across membranes of cotyledon cell (Woodstock, 1988). The HC was greater than Gangapuri in ICG 30 water soaked-fresh seeds and in ICG 6224 both water- and brine-soaked cured-seeds. ICG 6224 also had higher SC than Gangapuri for cured water and brine soaked seeds and fresh brine soaked seeds. Many other genotypes had greater SC than Gangapuri under different treatments.

Growing season had a profound effect on most of the seed characteristics. The produce of postrainy season had higher SW, SV, HC, and SC both for fresh- and cured-seeds and lower CT for fresh-seeds than rainy season. However, CT for cured-seeds of the former was higher than the latter. For fresh-seed boiling, the produce of postrainy and for cured-seed boiling the produce of rainy season should be preferred due to differences in their CTs. All valencia genotypes have 3- or 4-seeded pods among others. But their proportion in total pod composition may vary among genotypes. In the present set of genotypes, ICGs 58, 288, 326, 335, 408, 409, 1307, 1377, 1830, 1961, 3114, 3117, 3195, 3217, 6224, 6479, 7223, 10462, and 10900 had higher proportion of 4- and 3-seeded pods than other genotypes. But only ICGs 409 and 6224 scored over Gangapuri for shelling outturn, which determines edible yield, and 100- seed weight. For sweetness, ICGs 1377, 1830, 3117, 6479, and 7223 scored over others. ICG 1377 also had low oil content.

Many genotypes (ICGs 30, 326, 1307, 1377, 1693, 2148, 3114, 3195, 6224, 6479, and 7223) had 3 or more desirable characteristics associated with boiling use. ICG 6224 had ten desirable traits (greater HC for water soaked-cured pods, brine soaked cured-pods, water soaked cured-seeds, and brine soaked cured-seeds, greater SC for water soaked fresh-seeds and brine soaked cured-seeds, greater SW and SV for fresh seeds, higher proportion of 4-3 seeded pods with high shelling outturn, and greater 100-seed weight) followed by ICG 1307 which had four (greater HC for water soaked cured-pods, greater SD of cured-seeds and lesser CT of water soaked cured-seeds and brine soaked fresh-seeds). The rest had only 3 desirable traits. ICGs 319, 326, 2148, and 1307 had lesser CT than Gangapuri for pod and/or seed in at least two treatments.

The association between PW and CT was not clear. The lack of association between fresh PW and CT became a negative association on pre-soaking. On the contrary, the positive association between cured PW and CT disappeared on pre-soaking. In the case of cure-seeds, CT was positively associated with SW, SV, and SD. But in the case of fresh-seeds only SW and SD were positively associated and the magnitude of association was smaller than that of cured-seeds. There was reversal of association between CT and HC and SC on pre-soaking of fresh-seeds. In the case of water soaking, the association was positive but it became negative and smaller when seeds were soaked in brine. Only SC was positively associated with CT in case of brine soaked cured-seeds. HC and SC were not correlated with CT in water soaked cured-seeds.

Except for the preliminary knowledge of traits preferred by consumers in boiling type groundnuts, not much is known about their association with each other and with cooking time. Further, how these traits affect cooking time is also not well understood. More studies are required to address these issues.

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