J. Oilseeds Res., **22**(1) : 1-4 (2005)

Review Article

Confectionery groundnuts : issues and opportunities to promote export and food uses in India

S.L. Dwivedi and S.N. Nigam

International Crops Research Institute for the Semi-Arid Tropics, Patancheru-502 324, AP.

(Received: July, 2003; Revised: June, 2004; Accepted: September, 2004)

Abstract

Aflatoxin contamination, presence of chemical residues and high fat content have potential to adversely affect the use of groundnut as food worldwide. Substantial genetic variability exists for physical, sensory, chemical and nutritional traits in groundnut and efforts to incorporate these quality traits into different genetic background have been partially successful in India. With the availability of high oleic fatty acid germplasm in ICRISAT, it should now be possible for breeders in India to incorporate this unique trait into locally adapted cultivars by backcross breeding. The critical issues that may limit the progress in quality breeding are stability of seed mass, crop duration and seed mass, crop duration and degree of resistance, shelf-life and nutritional quality, and freedom from aflatoxin, and these issues must be addressed by plant scientists to make rapid progress in breeding for improved seed quality in groundnut. The confectionary groundnut trails in AICRPO-G should be taken into consideration for identifying varieties for release in India. Contract farming may be explored for commercial production of good quality nuts. A close linkage with farmers, processors/millers, exporters and consumers is vital for promoting export and enhancing domestic use of groundnut as food among rural folks in India.

Key words: Groundnut, *Arachis hypogaea*, quality breeding, seed mass, oil content, aflatoxin contamination, pesticides residues

Groundnut quality

Groundnut is a rich source of oil, protein, minerals and vitamins. Various physical, sensory, chemical and nutritional factors determine the quality of groundnut seed. Physical factors include consistency of seed mass and shape, integrity of seed testa, absence of foreign materials and immature seeds, integrity of the seed at the time of processing and blanching efficiency. Pod colour, size, shape and texture, cleanliness and freedom from damage and absence of blind nuts (pops) influence the quality of 'in-shell' boiled or roasted nuts. Sensory factors include seed colour, texture, flavour and wholesomeness. Chemical and nutritional factors include oil and protein contents, amino acid and fatty acid composition, carbohydrates, minerals and vitamins. Various end-uses also have their specific quality requirements. A confectionery groundnut cultivar must provide a consistent product.

Amino acids and monosaccharides are the precursor of roasted groundnut flavour. Aspartic, glutamic, glutamine, aspergine, histidine and phenylalanine are associated with the production of typical roasted flavour while threonine, tyrosine, lysine and unknown amino acids are associated with the production of atypical flavour in groundnut seed (Newell *et al.*, 1967).

Oleic (O) and linoleic (L) fatty acids together account for 75 to 80 % of the total fatty acids in groundnut seeds (Dwivedi *et al.*, 1993). O/L ratio and iodine value (IV) determine the shelf-life of oil and other groundnut products. The higher the O/L ratio and the lower the IV, the longer the shelf-life of groundnut oil and its products (James and Young, 1983; Branch *et al.*, 1990). The IV (the number of grams of iodine equivalent to halogen reacting with 100 g of lipid) measures the susceptibility of fatty acids to oxidation (rancidification). The acid value or percentage free fatty acid of a lipid indicates the extent of hydrolysis that has occurred in a fat. It is also related to the oxidative stability of the oil.

Challenges to quality in groundnut

Several factors are important in ensuring quality in groundnut products. These issues are particularly important in view of growing consumer awareness and concern about potential health hazards.

Aflatoxin: Aflatoxin contamination is a serious quality problem in groundnut. It is a key consideration in international trade; some countries demand complete freedom from aflatoxin in groundnut. Countries wishing to enter the edible trade market will have to ensure freedom from aflatoxin in their produce.

Chemical residues: Presence of chemical residues in food chain is increasingly attracting consumer's concern. Most edible-grade groundnut is generally grown under

high-input management, which includes the use of pesticides. Excessive use of pesticides can adversely affect the quality of the produce. Search for alternatives to chemical control and judicious use of pesticides requires immediate attention of scientific community.

Fat content: Because of health considerations, consumers prefer low-caloric foods and beverages. Technology to reduce the fat content in groundnut seed is available, but, it increases the cost of the finished product. Narrow genetic variability for oil content limits the scope for substantial reduction in oil through conventional breeding.

Certain other quality issues have relevance in the processing and marketing of groundnut products. The issues that most concern to manufactures are (i) excessive foreign material, (ii) seed mass consistency and (iii) the need to provide a reliable consistent product. Failure to address these concerns results in addition processing cost and difficulties in achieving quality levels. The marketing group, who are closest to consumers, seek (i) improved and specific flavour characteristics, (ii) maintenance of a good flavour and aroma throughout processing and on the shelf, (iii) reasonable shelf-life, (iv) improved appearance and (v) product distinctiveness.

Variability in seed quality traits

Physical and sensory traits: Large genetic variability exists for pod length (14-65 mm), pod width (7-20 mm), seed length (4-23 mm), seed width (5-13 mm), 100-seed mass (14-140 g) and seed colour (20 different colours) among the 14000 germplasm accessions evaluated at ICRISAT, Patancheru, India. The preferred seed colours for edible groundnuts are tan or red. Round or elongated seeds with tapering ends are preferred to those with flat ends.

Roasted groundnuts have characteristics flavour attributes. Various desirable (almond, coffee, fresh, nutty, popcorn, smoky and sweet) and off-flavour (aerid, astringent, barnyard, beany, bite, burnt, cardboard, earthy, green, machine oil, mealy, medicinal metallic, musty, onion, off-sweet, oily, rancid, raw, rotten, soapy, solvent, sour, stale, unclean and woody) attributes have been reported in roasted groundnut (Fletcher, 1987). Roasted groundnuts possess a firm and crispy texture. The consumers do not like soft or mushy roasted groundnuts.

Chemical and nutritional traits: In 8000 germplasm accessions analysed at ICRISAT, a range of 32% to 55% for oil and 16% to 34% for protein was observed. However, these ranges of variations were not maintained when selected genotypes with such variation were tested over seasons and locations (Dwivedi *et al.*, 1993). The O/L ratio among 200 germplasm lines of different botanical groups ranged from 0.84 to 1.36 in the Spanish/Valencia group and from 1.0 to 2.2 in the Virginia group. Two breeding lines originating from the natural mutation in Florida, USA, are reported to have very high O/L ratios (=40) (Norden *et al.*, 1987). However, this unique genetic material, because of the pending patent in USA is not available to other researchers for use in breeding. Using this natural variation for high O/L ratios, high yielding large-seeded cultivars such as Sun Oleic 95R and Sun Oleic 97R in USA have been released for commercial cultivation (Gorbet and Knauft, 1997; 2000). In South Africa, two breeding lines (PC 223-K8 and PC 223-K9) with high O/L ratios have been developed. ICRISAT has acquired the seeds of Sun Oleic 95R, PC 223-K8 and PC 223-K9. The former belongs to Virginia runner group while the later two belongs to Spanish bunch group. Groundnut researchers in India could acquired these lines from ICRISAT for use in breeding programmes.

Issues in quality breeding

Raising a good quality groundnut crop requires a high standard of crop husbandry. The crop should not suffer from diseases, insect pests and moisture and nutritional stresses. Further, in the Asian context, the crop duration should be short. Seed mass and productivity should be stable over years and locations. The gains of genetic improvement in quality breeding can easily be nullified by improper post-harvest handling of the crop. Improved post-harvest technology should be used for curing and drying the produce. The produce should be stored in good storage conditions to avoid post-harvest aflatoxin contamination.

There is a lack of full understanding of the quality parameters associated with different end uses. Manufactures and processors generally do not part with the information due to competition within the trade.

Stability of seed mass: Seed mass is highly influenced by genotype x environment interaction. The physiological reasons for such instability in seed mass are not well understood. Multilocational testing is essential to select (i) germplasm with stable seed mass for use in breeding and (ii) breeding lines with good seed quality for commercial exploitation.

Crop duration and seed mass: Most of the present day large seeded cultivars are of relatively long duration. Generally, as the seed mass increases the duration of the crop also increases. In the Asian context, short-duration cultivars with large seeds are required. A better understanding of the physiological processes involved in crop maturity and seed mass accumulation will help breeders to de-link this association between maturity duration and seed mass. Some progress has already been realised to develop breeding lines with early maturity and relatively large-seed (50-60 g/100 seed) at ICRISAT.

Crop duration and degree of resistance: Rust and leaf spots are the major foliar diseases of groundnut. In addition to causing substantial yield losses, they also affect seed quality adversely (Dwivedi *et al.*, 1996). Whenever genetic resistance to foliar diseases is

incorporated or the diseases are controlled by chemical means, the crop duration is increased. What level of genetic resistance should be incorporated into improved genotypes or what degree of chemical protection one should give to the crop without increasing the crop duration and impairing quality require more studies.

Shelf-life and nutritional quality: Both oleic and linoleic, the two unsaturated fatty acids are nutritionally important. Linoleic acid is also associated with the stability of oil and groundnut products. Groundnut products or oil obtained from cultivars with high linoleic acid content have shorter shelf-life than those obtained from cultivars with lower linoleic acid content. Oleic and linoleic acids are strongly negatively correlated (Dwivedi *et al.*, 1993). A balance between shelf-life and nutritional requirements should be aimed at in a breeding programme.

Freedom from aflatoxin: Genetic resistance to pre-harvest infection and in vitro seed colonization by *Aspergillus flavus* and aflatoxin production coupled with good crop husbandry helps to minimize aflatoxin contamination in groundnut. However, conventional methods are not sufficient to ensure complete freedom from this contamination. Current research on aflatoxin is focused on understanding its biosynthetic pathway to identify the precursor and enzyme that catalyze the conversion of this precursor into aflatoxin B1. Lipoxygenase (LOX) enzymes and their products could play a role in the *Aspergillus* - seed interaction. The C6-C12 products of the LOX pathway inhibit *Aspergillus* spore germination (Zeringue *et al.*, 1996) and metnyl asmonate inhibits aflatoxin biosynthesis but not fungal growth (Goodrich-Tanrikulu *et al.*, 1995). Peanut seed lipoxygenase gene has been cloned and characterized (Burow *et al.*, 2000). Some of the cloned genes of aflatoxin biosynthetic pathway can be effectively utilized to induce resistance to aflatoxin production. Excellent progress has been reported in development of an efficient tissue culture and transformation systems to introduce foreign DNA into groundnut (Sharma and Anjaiah, 2000) and work is in progress to develop transgenic groundnut with resistance to aflatoxin production at ICRISAT (K.K. Sharma, personal communication).

Prospects in quality breeding

With the availability of several high-yielding large-seeded sequentially branched breeding lines maturing earlier than many Virginia types and elite lines (Sun Oleic 95R, PC 223-K8 and PC 223-K9) with high O/L ratio (=10-20), it should now be possible to develop groundnut varieties that combine early maturity (100 days), large-seed size and high O/L ratio. Two duplicate recessive genes control high oleic acid in groundnut (Moore and Knauft, 1989) and it should be easy to transfer this trait into different genetic background by backcross breeding. Early maturing large seeded cultivars will have a prominent place in South and Southeast Asian agriculture. To make breeding efforts more directed, guidelines are required on minimum acceptance standards of various quality parameters.

Breeding efforts must accompany developments in crop husbandry. To achieve the potential of confectionery cultivars, a suitable package of production technology is required, which will address issues related to seed quality. The package must be environmentally safe and economical to adopt.

India - a case of missed opportunities

China, India, Indonesia, Myanmar and Vietnam in Asia, Nigeria, Sudan, Chad and Cango in Africa, USA in North America and Argentina in Latin America are the major producer of groundnut worldwide. However, the groundnut export is dominated by China, USA and Argentina. Until 1976, India contributed substantially to the world edible groundnut trade. However, in subsequent years export from India became almost negligible and this vacuum was filled mainly by China and Argentina. In the past groundnut was mainly crushed for edible oil in India with less than 5 per cent used for food purpose. There is now a growing interest for both to revive groundnut trade and also promote the use of groundnut as food crop.

The groundnut trade in the past in India was restricted to handpicked selected seeds from otherwise small-seeded cultivars, mainly because of non-availability of large-seeded cultivars with good seed quality. There is an urgent need to identify suitable cultivars with desirable traits to boost India's share of the world market and to promote the use of groundnut as a food among the rural folks in India. Policy decisions adversely affecting access to world markets act as a disincentive to growers, marketers and manufacturers. As the growers lose interest, the breeding efforts become redundant and are often discontinued. Continuity in breeding efforts in India is essential if we are to sustain and improve upon the achievements of genetic gains made so far in quality breeding. Until now the germplasm with high O/L ratios was not available to groundnut researchers in India. However, with the availability of such materials (Sun Oleic 95R, PC 223-K8 and PC 223-K9) at ICRISAT, it should now be possible for groundnut researchers in India to obtain these lines from ICRISAT for enhancing the seed quality of locally adapted groundnut cultivars in India. In many Asian countries including India freshly harvested groundnuts are boiled in saline water and eaten. Large-seeded Valencia groundnuts with 3-4 seeded pods are most preferred class for 'in-shell' boiled nuts use as they are low in oil and sweet in taste. Few germplasm lines (ICG 326, ICG 1307, ICG 2148 and ICG 6224) with such characteristics are available in ICRISAT gene bank (Dwivedi and Nigam, 2003).

There is also a need to revisit the way the trails for confectionery (edible grade) groundnuts are conducted under AICRPO-G. Indian programme in the past tested

several large-seeded breeding lines from its own programme as well as ICRISAT under AICORP-G trials. However, none of these could be identified for release mainly because of the faulty system of evaluation. Often these trials are conducted under sub-optimal conditions whereas production of good quality nuts requires that the crop should be grown under high input conditions (20:60:20 NPK/ha : gypsum application @ 400 kg/ha; full irrigation; full protection of pests and diseases) and the crop should be allowed to maturity. Superiority in pod yield has been the main criterion for variety identification ignoring the quality traits (uniformity in seed size and shape, oil content and O/L ratio). A few cultivars though identified and released but were unsuccessful on farmers' fields as these were of late maturity types and appropriate crop husbandry was not worked out for raising good quality nuts. To make the cultivation of confectionery groundnuts success in India, it is also necessary to map the growing regions in the country wherein the good quality groundnut could be grown with minimum risk of aflatoxin contamination. Contract farming may be explored in areas wherein the farmers have large-holdings, inputs are not the constraints and there exists a good infrastructure to take care of post-harvest curing, storage and marketing problems. Linking of farm produce directly with processors/millers and exporters should enable farmers to command a premium price to their good quality nuts. There is also a need to educate producers, processors, millers and exporters for problems/losses associated with post-harvest and storage conditions that often, if sub-optimal, deteriorate the seed quality in groundnut.

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