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RESEARCH ARTICLE

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Effects of grading on the main quality attributes of peanut kernels

Abstract Near infrared reflectance spectroscopy (NIRS) analysis of peanut kernels of different grades by mainly using advanced breeding lines derived from intersectional crosses in two experiments gave similar results, showing remarkable inter-grade variation in oil content of a specific entry. The effects of genotype on qualitative attributes proved to be predominant. No significant differences in protein content, oleic acid/linoleic acid content in total fatty acids, and oleic acid/linoleic acid ratio were detected among the No. 1, No. 2 and No. 3 grade peanut kernels of a given peanut genotype.

Keywords peanut, kernel grade, quality

1 Introduction

Peanut (*Arachis glabrata*) is cultivated as an important oilseed crop and cash crop in many developing countries, and also serves as a good source of protein for human beings.

It has been reported that the quality of peanut cultivars developed by conventional practices can be influenced by genotype, kernel size, soil type and climate factors (Pattee and Young, 1982; Mozingo et al., 1988; Wan, 2005). Mozingo et al. (1988) found a similar tendency in 5 US peanut cultivars, where the ratio of oleic acid to linoleic acid (O/L) of a specific variety consistently increased as the kernels got larger in size (Extra large > Medium > No. 1).

To broaden the narrow gene base of the cultivated peanut and to pursue an even high and stable yield, wild peanut relatives are being incorporated into more and more peanut improvement programs. Despite some varieties revealing compatibility with wild peanuts in their pedigree, there are few reports on quality studies involving such.

In 1989, fertile intersectional peanut hybrids were produced through *in vitro* culture of gynophores to rescue embryos that would otherwise abort early in their developmental stage (Shen et al., 1995), and new peanut breeding lines with yield potential much higher than or comparable to local peanut control Luhua 11 were bred. Our present study aims to ascertain the effects of grading on the qualitative characteristics of peanut kernels of these intersectional hybrid derivatives under mulch cultivation.

2 Materials and methods

2.1 Plant materials

The hybrid derivatives of peanut cultivars and wild peanut species used in this study involved 5 peanut cultivars (3 Virginia-type varieties: Luhua 10, Hua 37, 8130, 1 Valencia-type cultivar: Silihong, and 1 Spanish-type variety: 8122) and 2 peanut wild incompatible relatives (*Arachis rigonii* Krapov & W C Greg. and *A. glabrata* Benth. belonging to the Section Procumbentes and Section Rhizomatosae, respectively) (Table 1). The Virginia-type peanut cultivar Luhua 11 was utilized as control in the trial.

Table 1 Pedigree origin of peanut intersectional hybrid derivatives

identity of entry	pedigree
A1, A3, B6	8122×(Silihong×*A. glabrata* Benth.)F2
A2, A4	Luhua 10×(Silihong×*A. glabrata* Benth.)F2
B1, B2, B3, B4	Silihong×*A. rigonii* Krapov. & W. C. Greg
B5	Hua 37×(Silihong×*A. glabrata* Benth.)F2
B8	8130×(Silihong×*A. glabrata* Benth.)F2

2.2 Methods

A randomized block design trial consisting of 2 independent experiments, i.e. Experiment I and Experiment II

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(Tables 1 and 2), was used to appraise the performance of the advanced breeding peanut lines (Table 1), with a plot area of 12 square meters, 3 replications and a population of 150000 hills per hectare (2 seeds per hill). Among a total of 18 entries in the trial, 4 lines (A1, A2, A3 and A4) in Experiment I and 7 entries (B1, B2, B3, B4, B5, B6 and B7) in Experiment II were derived from intersectional crosses (Table 1). The others were derived from cultivated varieties and crosses of cultivated varieties (A5, A6, A7, A8, A9, B8, Luhua 11).

Table 2 Main qualitative attributes of peanut intersectional hybrid derivatives

identity	protein/ $(g \cdot kg^{-1})$	oil/ $(g \cdot kg^{-1})$	oleic acid (O)/$(g \cdot kg^{-1})$	linoleic acid (L)/$(g \cdot kg^{-1})$	O/L
A1	274.6bc	522.8abc	471.5b	344.7a	1.39b
A2	272.4c	511.1cd	479.3b	337.7a	1.44b
A3	278.6abc	519.9abc	456.5b	355.7a	1.30b
A4	275.7bc	519.2bcd	468.1b	345.3a	1.38b
A5	286.3a	515.5bcd	537.6a	284.1b	1.92a
A6	282.4ab	511.4cd	463.4b	348.2a	1.35b
A7	277.0bc	527.2ab	495.1b	321.6a	1.55b
A8	279.2abc	520.2abc	478.4b	334.8a	1.44b
A9	278.9abc	531.6a	479.4b	334.8a	1.45b
Luhua 11	278.7abc	507.4d	558.9a	269.5b	2.09a
B1	277.5ab	503.1d	529.0b	296.2c	1.84b
B2	266.6cde	513.9abcd	541.9ab	283.8cd	1.93b
B3	263.5de	520.6ab	542.4ab	285.4cd	1.92b
B4	261.6e	510.5bcd	564.1a	263.4d	2.18a
B5	276.2ab	504.5d	521.9b	300.6c	1.75b
B6	270.9bcd	524.0a	476.8cd	336.6b	1.43cd
B7	268.9bcde	517.5abc	484.2c	331.1b	1.49c
B8	284.3a	507.8cd	452.2d	360.3a	1.27d
Luhua 11	273.0bc	507.0cd	542.5ab	285.3cd	1.93b

Note: Means of specific trait within the same column followed by different small letters mean significant difference at 0.01 probability level.

The seeds were sown under polythene (with Acetochlor) mulch at the Experimental Station of the Shandong Peanut Research Institute (SPRI), Shandong Province, China, on May 6, 2006 after rain fell. Weeds were pulled up by hand, and pesticide was sprayed on the soil a week before wheat (*Triticum aestivum*) harvest (Wan, 2003). No irrigation was applied although the crop encountered slight drought at the primary flowering and pod-filling/maturing phases. The peanuts were harvested on September13, 2006.

Five-hundred grams of randomly selected peanut pod samples from each plot were hand-shelled and screen-graded. No. 1 kernels were sound mature seeds riding on a #9 screen (product of Qingdao Newart Peanut Machinery Co. Ltd, China). No. 2 size kernels were sound mature seeds retained by a #8 screen but falling through a #9 screen. No. 3 size kernels were sound mature seeds retained by a #7 screen but falling through a #8 screen.

The protein and oil contents, and oleic/linoleic acid contents (percentages of total fatty acids) in seeds were quantitatively determined by near infrared reflectance spectroscopy (NIRS) using a Matrix^{TM}-E spectrometer (Bruker Optics, Germany) based on the models available (Yu et al., 2003a, 2003b; Wang et al., 2006). The integrating sphere module has a sampling area of 20 mm in diameter. The internal diameter of the rotating sample cup assembly was 5 cm. Wavelengths were1000–2500 nm. Each sample was measured 3 times, and the average was used for subsequent statistical analysis.

For statistical analysis, the experiment was treated as a split-plot design with genotype as the first factor (main factor) and grade as the second factor. Analysis of variance (ANOVA) and multiple comparisons by Duncan's multiple range test (Quinn and Keough, 2002) was conducted using the SAS package (Statistical analysis software for Windows. Version 8.1, 2000).

3 Results

Results from ANOVA showed a similar trend in both experiments. While all of the internal qualitative attributes inclusive of the protein content, oil content, oleic and linoleic content (percentage of total fatty acids), and O/L ratio of different genotypes varied significantly, the interaction of genotype and grade, however, was not statistically significant, and the between-grade variation was only significant for oil content (Tables 2 and 3).

The oil content in peanut kernels of different grades exhibited a consistent tendency throughout the experiments. On average, No. 1 grade peanut kernels contained about 1.5% oil higher than No. 2 grade peanuts, and No. 2 grade peanut kernels contained around 2% oil higher than No. 3 grade peanuts (Table 3).

Table 3 Variation in oil content of peanut kernels from different grades ($g \cdot kg^{-1}$ dry basis)

grade	average oil content in Experiment I	average oil content in Experiment II
No. 1	535.2a	528.7a
No. 2	520.5b	513.8b
No. 3	500.1c	493.8c

Note: Means of specific trait within the same column followed by different small letters mean significant difference at 0.01 probability level.

3.1 Experiment I

In Experiment I, the protein content ranged from 27.24% to 28.63%. All of the breeding lines in Experiment I contained protein comparable to the local line Luhua 11. The oil content varied from 50.74% to 53.16%. All of the other lines had oil content significantly higher than Luhua

11 except for A2, A4, A5 and A6. A5 had similar fatty acid profiles to Luhua 11, whereas other breeding lines contained less oleic acid and more linoleic acid in total fatty acids, leading to a much lower O/L ratio as compared to Luhua 11 (Table 2). Linoleic acid is beneficial to human health, but a lower O/L ratio is generally recognized as an indicator of poor storing quality.

3.2 Experiment II

The range of protein content in Experiment II was from 26.16% to 28.43% (Table 2). B8 was the only breeding line in Experiment II, with protein content significantly higher than that of the local control Luhua 11. The oil content varied from 50.31% to 52.40%. The oil contents of B3 (52.06%) and B6 (52.40%) were both significantly higher than Luhua 11. Other lines contained oil equivalent to Luhua 11. B6, B7 and B8 contained less oleic acid and more linoleic acid in total fatty acids than Luhua 11, no doubt resulting in significantly lower O/L ratio. B4 was an exceptional case, whose O/L ratio was 2.18, much higher than that of Luhua 11 (Table 2).

4 Discussion

In contrast to the early report by Mozingo et al. (1988), where larger US peanut kernels of the same cultivar contained significantly more oleic acid and less linoleic acid in total fatty acids without film mulch, our study unexpectedly demonstrated that as far as oleic acid and linoleic acid are concerned, the fatty acid profile of a specific entry in 2 independently designed experiments conducted in China with film mulch was proved regardless of the grade of kernels. Interestingly, Experiment I and Experiment II, using different hybrid derivatives, yielded similar results, providing a cross check thus making the results even more reliable. The discrepancy between our study and Mozingo's report was probably due to different cultural practices, as previously confirmed by other researchers, wherein film mulch cultivation might create a micro-ecological environment quite different from the uncovering cultivation and eventually bring about remarkable changes in peanut development (Wan, 2003). Nevertheless, we still do not know if utilization of most Chinese peanuts from an intersectional hybrid origin instead of using US peanut, and the use of screens with different specifications in our study contributed more or less to the distinction.

Chinese researchers have already stated that the harvest date, film mulch and seed maturity degree might affect the peanut's internal quality, but unfortunately, no statistical means were exploited, making the conclusion have low stringency (Wan, 2005). As compared with conventional protocols for the analysis of peanut kernel quality using the Soxhlet oil extraction method, Kjeldhal nitrogen determination procedure, and gas chromatography for fatty acids, requiring high input and much time, the NIRS method is fast, low-cost and accurate and can determine several qualitative attributes at one time, which makes it therefore feasible to obtain adequate data for statistical analysis to obtain meaningful results. Our study revealed the inter-grade difference in oil content of a specific peanut genotype, indicating that different sampling methods may have much influence on the results of oil content analysis of peanut kernels.

In addition, the utility of wild incompatible species in peanut quality improvement was verified. In view of the results from the present study, it is possible to breed peanuts with kernel protein content, oil content or O/L ratio comparable to or even higher than these of the local control Luhua11 using wild *Arachis* species.

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