Resveratrol, total phenolic and flavonoid contents, and antioxidant potential of seeds and sprouts of Korean peanuts

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Abstract Peanut sprouts are gaining increasing popularity as a potential source of functional food. The objective of this study was to investigate yield and food value of peanut sprouts of six Korean peanut genotypes (Daekwang, Akwang, Baekjung, Alogi, Pungan and Heugttangkong) from day 5 through 9. Functional compounds like polyphenol, flavonoid, and resveratrol contents were significantly ($p < 0.05$) high in the sprouts compared to those in the seeds. Pungan yielded significantly ($p < 0.05$) high sprouts followed by Alogi. However, antioxidant potentials and functional compounds in the sprouts varied significantly ($p < 0.05$) with genotype, sprout part, and day after germination. Overall consideration of the yield, functional compounds, and antioxidant potentials of the sprouts suggested that more appropriate time of sprout harvest for Alogi and Pungan was day 5–7 and that for the other genotypes was day 5–8. The yield and functional properties of peanut sprouts significantly varied with genotypes, parts, and age.

Keywords Antioxidant potential · Functional compounds · Genotypes · Peanut sprout · Resveratrol

Introduction

Peanut (*Arachis hypogaea* L.) is one of the widely grown oilseed and legume crops. Peanut seeds contain approximately 48% fat, 30% protein, 15.5% carbohydrates, 3% crude fibers, and 2% ash [1]. Peanut seeds and their products are the rich sources of different functional food components. They are also a good source of minerals like calcium, phosphorous, copper, and magnesium as well as vitamins like vitamin C, thiamin, niacin, riboflavin, vitamin D, and vitamin K [2]. Consumption of peanut reduced the risk of coronary heart diseases, cancers, diabetes, respiratory diseases, and mortality as well as was effective to lower the body fat and weight [3]. In addition, peanuts are a good source of antioxidants as they contain various phenolic and other bioactive substances like resveratrol, flavonoids, p-coumaric acid, isoflavones, phyto-sterols, and phytic acid [4]. Phenolic compounds are good antioxidants and play significant roles in protection against various diseases like diabetes, asthma, cardiovascular diseases, cancers, aging, and infections [5]. Resveratrol is a major stilbene phytoalexin phenolic compound that exists mainly in trans- and cis-isomeric forms [6] and is considered to have various health benefits. Only a very few edible plants, including peanuts, are known to contain the trans-resveratrol. Recently, the resveratrol-containing foods are gaining wide public interests due to their health benefits against the risks of cardiovascular disease, cancer, Alzheimer's disease, diabetes, obesity, and inflammation [7].

Sprouts can easily be grown with many crop seeds at the household or industrial level without any expensive equipment. Unlike other vegetables, sprouts could be grown in considerably short time year-round. The sprouts have a unique taste and are rich in nutrients like proteins, sugars, minerals, vitamins, amino acids, fats, and fibers [8].

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They are also good sources of antioxidants because of their high phenolic, anthocyanin, and flavonoid contents [9]. Peanut sprouts contain higher amounts of carbohydrates, amino acids, minerals, and phenolic compounds but the lower amount of fats than the seeds [10]. Moreover, the peanut sprouts are a good source of resveratrol, a natural phytoalexin phenolic compound [11], which is found only in a few crop species.

Although a large number of studies on soybean sprouts have been carried out, very limited reports on peanut sprouts of Korean cultivars have been published. To date, no report on a day-wise comparative study of peanut sprouts of Korean cultivars was found. The objectives of the present study were to investigate the yield and to analyze resveratrol and other phenolic contents as well as antioxidant potentials of sprout cotyledon and other part of four cultivars and two breeding lines of peanut from day 5 through 9.

Materials and methods

Seed material

Six Korean peanut seeds namely; Daekwang, Akwang, Baekjung, Alogi, Pungan, and Heugttangkong; were obtained from Gyeongsangbukdo Agricultural Research and Extension Services, Daegu, Korea in September 2016. Alogi and Heugttangkong are the promising breeding lines which have not been released as cultivar yet. Other four peanut seeds are among the widely grown cultivars by the Korean farmers, and have different seed sizes (Table 1). The yield of Daekwang, Akwang, Baekjung, and Pungan are 2.68, 3.66, 3.48, and 4.67 ton/ha, respectively.

Chemicals and reagents

Folin-ciocalteu reagent, 2,2-diphenyl-1-picrylhydrazyl (DPPH), sodium carbonate (Na_2CO_3), sodium hydroxide (NaOH), aluminium chloride (AlCl_3), quercetin, 2,2'-azino-bis (3-ethylbenzothiazoline-6-sulphonic acid), and potassium persulfate were purchased from Sigma Chemicals, USA. All the chemicals and reagents used in this study were of analytical grade.

Sprout growing

One hundred grams of intact seeds, in three replications, of each cultivar and the breeding line were soaked in tap water at 30 °C for 10 h. The water was drained off after 10 h and the seeds were put into 3-L plastic buckets having the perforated base for sprouts production. Peanut sprouts were grown according to the method described by Miao et al. [12] with some modifications. The buckets containing seeds or sprouts were sprinkled with tap water using two hoses of 1-cm diameter for 2 min every 6 h. The sprouts were grown at room temperature (22–25 °C) for 9 days.

Sprout length and yield

Sprout lengths and yields were recorded from day 5–9. The sprout yield was considered as the weight of germinating seeds in each bucket. The yield was measured by deducting the weight of blank buckets from the weight of each bucket containing germinating seeds. The lengths of randomly selected 15 sprouts were measured using a digital caliper for statistical analysis.

Sample preparation and extraction

The sprouts (from day 5 to 9) were kept into deep freeze (–70 °C) before subjected to freeze-drying. One hundred

Table 1 Hundred-seed weight, DPPH, and ABTS radical scavenging potentials, and polyphenol, flavonoid and resveratrol contents of seeds of peanut four cultivars and two breeding lines

Cultivar	100-seed weight (g)	DPPH (%)	ABTS (%)	Polyphenol (μg GAE/g)	Flavonoid (μg QE/g)	Resveratrol ($\mu\text{g/g}$)
Daekwang	83.1 $\pm$ 0.6 ^{cd}	85.1 $\pm$ 0.3 ^a	45.0 $\pm$ 0.17 ^a	528.1 $\pm$ 4.4 ^a	65.9 $\pm$ 1.9 ^c	1.3 $\pm$ 0.02 ^d
Akwang	85.3 $\pm$ 2.8 ^c	80.2 $\pm$ 1.2 ^b	40.9 $\pm$ 1.1 ^b	521.3 $\pm$ 2.5 ^a	52.7 $\pm$ 3.2 ^d	0.8 $\pm$ 0.01 ^f
Baekjung	99.4 $\pm$ 2.1 ^a	69.4 $\pm$ 1.5 ^c	44.4 $\pm$ 0.5 ^{ab}	283.8 $\pm$ 2.0 ^c	26.0 $\pm$ 3.2 ^e	1.1 $\pm$ 0.004 ^e
Alogi	66.5 $\pm$ 1.0 ^e	33.0 $\pm$ 0.8 ^e	14.4 $\pm$ 1.2 ^e	153.3 $\pm$ 0.8 ^e	81.8 $\pm$ 4.8 ^b	2.1 $\pm$ 0.04 ^a
Pungan	92.2 $\pm$ 1.0 ^b	73.5 $\pm$ 1.8 ^c	30.6 $\pm$ 2.5 ^c	347.7 $\pm$ 2.2 ^b	43.1 $\pm$ 0.7 ^d	1.9 $\pm$ 0.004 ^c
Heugttangkong	79.3 $\pm$ 1.9 ^d	44.1 $\pm$ 1.9 ^d	22.0 $\pm$ 0.3 ^d	236.2 $\pm$ 1.6 ^d	133.9 $\pm$ 3.7 ^a	2.0 $\pm$ 0.02 ^b

The values are expressed as mean $\pm$ SE (n=3). The mean values followed by different superscripts in the same column are significantly different ($p<0.05$)

GAE gallic acid equivalent, QE quercetin equivalent

grams of intact seeds were also freeze-dried. After freeze-drying, the sprouts were separated into two parts, sprout cotyledons (SC) and sprouts without cotyledon (SWC), for further analysis. The SC and SWC were separately ground into powders using a commercial grinder (HIL-G-501, Hanil Co., Seoul, Korea). The powdered samples were kept in air-tight polyethylene bags and stored at -20°C . The extraction of samples was done as described by Yu et al. [13] with some modifications. The powdered samples were extracted in absolute methanol (1:10 w/v) using a shaking incubator (25°C , 150 rpm) for 6 h and centrifuged ($13,000\times g$) at room temperature for 10 min. The supernatant was filtered through a syringe filter ($0.2\text{ }\mu\text{m}$) and stored at -20°C .

Antioxidant activities assay

The DPPH radical scavenging activities of sample extracts were measured according to Wang et al. [14] with some modifications. An equal volume (100 μL) of sample extracts and freshly prepared 0.1% DPPH solution in absolute methanol were mixed in the microplates and kept for 30 min at room temperature in dark. The absorbance was taken at 517 nm using a spectrophotometer (Multiskan GO, Thermo Fischer Scientific, Vantaa, Finland). The DPPH radical scavenging activity was calculated using following equation:

$$\text{DPPH scavenging ability (\%)} = [1 - (A_1 - A_2)/A_3] \times 100$$

where, A_1 is absorbance of sample extract and DPPH, A_2 is absorbance of sample extract and absolute methanol, and A_3 is absorbance of DPPH and absolute methanol.

The ABTS radical scavenging activity of sample extracts was carried out according to the method described by Re et al. [15] with some modifications. The radical cation of ABTS (ABTS^+) was produced by mixing an equal volume of potassium persulfate (2.5 mM) and ABTS (7 mM) and incubating in the dark for 16 h. The solution was diluted by mixing double distilled water (1:20 v/v) to get the absorbance value near to 0.7. Twenty microliters of sample extracts were mixed with 180 μL of ABTS solution and absorbance was measured at 734 nm using a spectrophotometer (Multiskan GO, Thermo Fischer Scientific). The ABTS radical scavenging activity was calculated using the following equation:

$$\text{ABTS radical scavenging activity (\%)} = [(ABTS_{\text{Ctrl}} - ABTS_{\text{Sample}})/ABTS_{\text{Ctrl}}] \times 100$$

where, $ABTS_{\text{Ctrl}}$ is the absorbance of ABTS radical cation and $ABTS_{\text{Sample}}$ is the absorbance of a mixture of ABTS radical solution and sample extract.

Total polyphenol content

The total polyphenol content of peanut seeds and sprouts were determined using Folin-Ciocalteu reagent following the procedure of Zheng and Wang [16] with some modifications. Fifty microliters of sample extract were mixed with 1 mL of Na_2CO_3 (2%) using a vortexer. A 50- μL of 1 N Folin-Ciocalteu reagent was added to the mixture and allowed to stand for 30 min at room temperature in dark. The absorbance was taken at 750 nm using a spectrophotometer (Multiskan GO, Thermo Fischer Scientific). The total polyphenol content was determined using gallic acid as a standard and the results were expressed as microgram gallic acid equivalents per gram dry weight sample ($\mu\text{g GAE/g dry weight sample}$).

Total flavonoid content

The total flavonoid content was measured following the method described by Li et al. [17] with some modifications. Three hundred microliters of sample extract was mixed with 300 μL of double distilled water and then 30 μL of NaNO_2 (5%) was added to the mixture. The mixture was allowed to react at room temperature for 5 min and then 60 μL of AlCl_3 (10%) was added to the mixture. After 5 min, 200 μL of NaOH (1 M) was added to the mixture and vortexed. The absorbance reading was taken at 500 nm using a spectrophotometer (Multiskan GO, Thermo Fischer Scientific). The total flavonoid content was calculated from the calibration curve plotted using quercetin as a standard, and expressed in microgram quercetin equivalents per gram dry weight sample ($\mu\text{g QE/g dry weight sample}$).

Resveratrol content

The resveratrol content of peanut seeds and sprouts was analyzed using a high-performance liquid chromatography (HPLC) as described earlier [18]. One milligram of the powdered sample was extracted in 1 mL absolute methanol. A multistep gradient method was applied, using solvent A (methanol/water/acetic acid mixture) and solvent B (methanol/water/acetic acid mixture). The detection wavelength was set at 306 nm. The solvents used were of HPLC grade. Resveratrol contents of the samples were identified by their retention times and calculated by comparing their peak areas with those of the standards. The resveratrol content was expressed in $\mu\text{g/g dry weight sample}$.

Statistical analysis

All the data are presented as a mean $\pm$ standard error (SE). Analysis of variance test was conducted using PROC GLM

in SAS 9.4 (SAS Institute Inc., Cary, NC, USA). The significant differences among treatment means were identified by Student's *t*-test at 0.05 probability level. The correlations between antioxidants and phenolic compounds were calculated using PROC CORR in SAS 9.4. All the values are averages of triplicate experiments unless otherwise mentioned.

Results and discussion

Sprout length and yield

Significant ($p < 0.05$) variations in the lengths and yields of sprouts were observed among the four cultivars and two breeding lines from day 5 to 9 (Figs. 1, 2). Alogi had the longest sprouts on day 6 and 9, whereas Pungan had the longest on day 5, 7, and 8. As in the case of sprout yield, Alogi produced significantly ($p < 0.05$) high amount of sprouts followed by Pungan. The sprouts with longer epicotyls and larger lateral roots look rough and are not preferred by customers [19]. The quality of sprouts is judged based on their appearance, palatability, and nutrient and phytochemical contents. The higher sprout yield of Alogi might be due to the lower 100-seed weight (Table 1), resulting in more number of sprouts per unit weight of seed [19]. However, this assumption was not true for Pungan which had higher 100-seed weight than Daekwang, Akwang, and Heugttangkong but also yielded the higher amount of sprouts than them. The high sprout yield of Pungan might be due to rapid sprout growth (Fig. 1). The results showed that peanut cultivars and breeding lines having smaller seed size or rapid growth rate could be economically efficient for getting higher sprout yields. Some of the cultivars and breeding lines had excessive sprout growth on day 8 and 9 which showed deteriorated eating and marketing quality [20].

Antioxidant potentials

The antioxidant potentials of seeds and sprouts components were assayed through DPPH and ABTS (Tables 1, 2). The DPPH and ABTS values of the seeds ranged 33.0–85.1 and 14.4–45.0%, respectively, in which Daekwang had the highest value and Alogi had the lowest. The DPPH and ABTS of SC and SWC varied significantly ($p < 0.05$) among cultivars and breeding lines from day 5 through 9. The SWC showed higher DPPH and ABTS scavenging potential than the SC in all the four cultivars and two breeding lines during the period. The DPPH radical scavenging activities of SC and SWC on day 5 ranged 15.4–22.7 and 77.8–89.3%, respectively. The value ranged 25.4–37.5 and 81.7–92.2% on day 9 for the SC and SWC, respectively. The DPPH value for SWC did not show any consistent trend from day 5 through 9. The ABTS radical scavenging activities of SC and SWC on day 5 ranged 5.7–29.6 and 55.9–71.4%, respectively. The value ranged 28.5–47.5 and 59.7–74.8% on day 9 for SC and SWC, respectively. As the DPPH value, the ABTS value of SWC did not show any consistent trend from day 5 through 9. During seed germination process different secondary metabolites are produced due to various biochemical and physiological changes in the seeds [21]. A good correlation was found between DPPH and ABTS scavenging activities in the SC ($r = 0.570$) and SWC ($r = 0.354$). The DPPH and ABTS share the basic mechanism of antioxidant activities which might be the reason for the correlation [22]. Sprouts of all the four cultivars and two breeding lines from day 5 to 9 had high DPPH and ABTS radical scavenging activities. Results of the present study also agree with that of the previous report on peanut sprouts [23].

Total polyphenol and flavonoid contents

The variation trend of total polyphenol was similar to that of total flavonoid contents in all the four cultivars and two breeding lines (Tables 1, 3). The total polyphenol and flavonoid contents of seeds ranged 153.3–528.1 $\mu\text{g GAE/g}$

Fig. 1 Sprout lengths of peanut four cultivars and two breeding lines from day 5–9. Different letters above bar diagram in the same day are significantly different ($p < 0.05$)

Fig. 2 Sprout yields of peanut four cultivars and two breeding lines from day 5–9. Different letters above the bar diagrams in the same day are significantly different ($p < 0.05$)

and 26.0–133.9 μg QE/g, respectively. The seeds of Daekwang had the highest and Alogi had the lowest total polyphenol content, whereas the flavonoid content was highest for Heugttangkong and the lowest for Baekjung seeds. The total polyphenol contents of SC and SWC on day 5 ranged 160.6–261.6 and 549.9–722.6 μg GAE/g, respectively; whereas the values ranged 230.6–320.9 and 637.1–723.4 μg GAE/g on day 9 for SC and SWC, respectively. The total polyphenol content of SC and SWC did not show any consistent trend from day 5 through 9. Total flavonoid contents of SC and SWC on day 5 ranged 63.0–105.3 and 311.7–730.8 μg QE/g, respectively; whereas the values ranged 52.0–105.5 and 367.3–532.6 μg QE/g on day 9 for SC and SWC, respectively. The total polyphenol content had significant ($p < 0.05$) positive correlation with the DPPH ($r = 0.635$) and ABTS ($r = 0.687$) in SC, whereas the flavonoid content had non-significant ($p > 0.05$) positive correlation with DPPH assay ($r = 0.520$) in SWC. The positive correlations might be due to the high antioxidant potentials of phenolic compounds [24]. The SWC showed significantly ($p < 0.05$) high polyphenol and flavonoid contents as compared to the SC and seeds since the phenolic compounds are associated with the cell wall formation and plant growth [25]. High phenolic compound production during sprouts growth might be the reason for higher polyphenol contents in SWC than in the SC and seeds.

Resveratrol content

The resveratrol content in seeds as well as in sprouts significant ($p < 0.05$) varied among the four cultivars and two breeding lines (Tables 1, 4). The resveratrol content of seeds ranged 0.8–2.1 $\mu\text{g/g}$ with the highest value for Alogi and the lowest for Akwang. The resveratrol content in SC and SWC varied significantly ($p < 0.05$) among cultivars and breeding lines from day 5 through 9. The SWC contained higher amount of resveratrol than the SC for all the four cultivars and two breeding lines during this period.

The resveratrol content of SC and SWC on day 5 ranged 4.1–7.9 and 42.3–56.2 $\mu\text{g/g}$, respectively. Resveratrol content ranged 2.9–11.4 and 27.1–53.9 $\mu\text{g/g}$ on day 9 for SC and SWC, respectively. Variations in the resveratrol content in SC and SWC was not consistent from day 5 through 9. The polyphenol, flavonoid, and resveratrol contents in the sprouts were correlated with each other. Flavonoid showed a positive correlation with polyphenol content ($r = 0.332$) and polyphenol also had a positive correlation with resveratrol content ($r = 0.267$) in the SC. Resveratrol content significantly ($p < 0.05$) varied with genotype, part, and germination day of the sprouts. Results of the present study agree with the previous report [26] for the variation in resveratrol contents.

Generally, peanut sprouts are harvested after day 5 of incubation for germination. Different studies show that the peanut sprouts possess the optimum amount of nutrients and other phytochemicals on varying days starting from day 5. Miao et al. [12] obtained optimum resveratrol content in the peanut sprouts on day 5. Lee et al. [20] found the highest resveratrol content on day 9. Kang et al. [23] reported the total polyphenol and antioxidant activities of peanut sprouts on 9 days. Similarly Kang et al. [27] studied the resveratrol and nutrient contents of peanut sprouts on day 3, 6, and 9. Pae et al. [19] evaluated the growth characteristics and nutrient content of sprouts of 37 peanut cultivars on day 7.

Quality of the peanut sprouts could be evaluated on the bases of sprout yield, appearance, and nutrient value including antioxidant potential, total polyphenol, flavonoid, and resveratrol contents. Although the antioxidant activities and polyphenol contents were increased after day 7, in comparison to the other three cultivars and one breeding line, Alogi and Pungan had large lateral roots and rough appearance which might be less preferred for consumption (data not shown). Very limited information is available on the antioxidant activity and secondary metabolites of different parts of peanut sprouts. The changes in the chemical composition of seeds during germination bring an

Table 2 DPPH and ABTS radical scavenging potentials of different parts of peanut sprouts from day 5 to 9

Cultivar and breeding line	D5			D6			D7			D8			D9			Cultivar and breeding line-wise mean value	
	SC	SWC		SC	SWC		SC	SWC		SC	SWC		SC	SWC		SC	SWC
<i>DPPH radical scavenging potential (%)</i>																	
Daekwang	22.7±1.2 ^{aC}	85.5±0.9 ^{bb}		40.8±0.4 ^{aA}	74.3±1.9 ^{dd}		23.2±1.7 ^{bcC}	83.1±1.22 ^{bbc}		32.9±3.84 ^{aB}	80.3±1.37 ^{abc}		32.0±1.2 ^{abb}	92.2±0.1 ^{uA}		30.3	83.1
Akwang	15.4±0.4 ^{cC}	89.3±0.5 ^{uA}		35.0±3.6 ^{abA}	86.3±1.2 ^{bb}		23.3±1.1 ^{bcB}	89.1±1.88 ^{uA}		26.2±1.65 ^{abB}	79.3±0.75 ^{abc}		26.5±1.5 ^{bcB}	84.3±0.9 ^{bb}		25.3	85.7
Baekjung	18.2±0.3 ^{bb}	77.8±1.0 ^{bcC}		26.9±4.0 ^{bA}	81.5±1.3 ^{bcC}		20.9±0.8 ^{uAB}	75.2±1.69 ^{cC}		23.2±3.51 ^{bAB}	63.5±2.2 ^{5CD}		25.4±1.1 ^{cAB}	89.1±1.9 ^{abA}		22.9	77.4
Alogi	22.2±0.6 ^{bc}	84.1±0.1 ^{bbc}		37.5±3.1 ^{uA}	90.8±0.2 ^{uA}		27.6±1.7 ^{bbc}	86.8±0.61 ^{abb}		27.4±3.09 ^{abBC}	80.1±1.7 ^{bbD}		33.6±2.4 ^{abB}	82.8±2.2 ^{bcD}		29.7	84.9
Pungan	17.6±0.4 ^{bb}	86.8±0.14 ^{bA}		38.7±3.5 ^{uA}	91.0±0.4 ^{uA}		34.1±2.7 ^{uA}	87.3±1.56 ^{abA}		35.0±3.0 ^{uA}	83.0±2.5 ^{uA}		37.5±1.8 ^{uA}	87.3±4.9 ^{abA}		32.6	87.0
Heugttangkong	NA	NA		38.2±1.9 ^{uA}	74.5±0.3 ^{db}		16.9±1.5 ^{dc}	76.9±2.0 ^{cAB}		25.9±2.33 ^{abB}	74.8±1.6 ^{bb}		27.3±2.7 ^{bcB}	81.7±2.5 ^{bA}		27.1	77.0
Day-wise mean value	19.2	84.6		36.2	83.1		24.3	83.1		28.4	76.8		30.4	86.2			
<i>ABTS radical scavenging potential (%)</i>																	
Daekwang	9.6±1.71 ^{cC}	55.9±2.6 ^{bbc}		9.7±0.9 ^{cC}	52.7±2.4 ^{dc}		13.2±0.7 ^{dB}	58.5±0.3 ^{dB}		28.8±1.1 ^A	65.4±1.4 ^{bA}		29.7±0.5 ^{cA}	68.8±1.1 ^{bA}		18.2	60.3
Akwang	5.7±1.21 ^{dd}	58.7±1.7 ^{bc}		20.8±0.4 ^{bb}	63.6±1.3 ^{bcAB}		15.9±1.2 ^{cC}	60.8±1.2 ^{bbc}		28.2±1.3 ^{dA}	66.4±1.6 ^{bA}		28.5±0.6 ^{cA}	64.4±1.5 ^{AB}		19.8	62.8
Baekjung	8.4±1.54 ^{cd}	58.7±1.6 ^{bb}		10.6±2.2 ^{cd}	56.4±1.8 ^{dB}		14.7±0.9 ^{dc}	59.4±1.4 ^{bb}		23.2±1.5 ^{dB}	66.6±1.1 ^{bA}		29.5±1.7 ^{cA}	65.7±0.86 ^{cA}		17.3	61.4
Alogi	22.9±0.2 ^{bc}	60.5±1.5 ^{bbc}		31.4±1.3 ^{ab}	64.5±2.3 ^{abAB}		25.5±0.7 ^{bc}	61.1±0.3 ^{bbc}		33.2±1.4 ^{abB}	67.1±1.3 ^{bA}		35.5±0.8 ^{bA}	59.7±0.5 ^{dc}		29.7	62.6
Pungan	29.6±0.76 ^{cC}	71.4±0.2 ^{uAB}		30.6±2.7 ^{cC}	69.6±1.8 ^{dB}		37.8±0.1 ^{dB}	65.0±0.9 ^{cC}		46.7±0.6 ^{uA}	72.9±1.7 ^{uAB}		47.5±2.6 ^{uA}	74.8±0.8 ^{uA}		38.4	70.7
Heugttangkong	NA	NA		24.6±1.9 ^{bb}	58.0±1.8 ^{cdB}		13.9±0.5 ^{dc}	50.3±0.8 ^{cC}		31.7±0.1 ^{bcA}	64.2±1.1 ^{bA}		33.4±2.3 ^{bcA}	60.1±0.6 ^{dB}		25.9	58.2
Day-wise mean value	15.2	61.0		21.3	60.8		20.2	59.2		32.0	67.1		34.0	65.6			

The values are expressed as mean±SE (n=3). The mean values followed by different lowercase superscripts (a–d) in same column and different uppercase superscripts (A–D) for same sprout components (cotyledon or SWC) in the same row are significantly different ($p<0.05$)

SC sprout cotyledon, SWC sprout without cotyledon, NA Not available due to missing data

Table 3 Polyphenol and flavonoid content of different parts of peanut sprouts from day 5 to 9

Cultivar and breeding line	D5			D6			D7			D8			D9			Cultivar and breeding line-wise mean value	
	SC	SWC	SC	SWC	SC	SWC	SC	SWC	SC	SWC	SC	SWC	SC	SWC	SC	SWC	SC
<i>Polyphenol content (μg GAE/g)</i>																	
Daekwang	258.9±2.6 ^{bb}	717.1±3.6 ^{aa}	241.8±1.3 ^{dc}	620.9±2.4 ^{cc}	166.5±2.8 ^{dd}	583.1±4.1 ^{bd}	274.1±6.9 ^{ba}	643.5±9.2 ^{cb}	264.1±3.2 ^{cdAB}	722.8±6.2 ^{aa}	241.1	722.8±6.2 ^{aa}	264.1±3.2 ^{cdAB}	722.8±6.2 ^{aa}	241.1	657.5	657.5
Akwang	160.6±0.8 ^{cc}	722.6±6.3 ^{aa}	257.6±3.9 ^{ca}	678.0±5.9 ^{bb}	175.7±1.8 ^{cb}	609.6±6.5 ^{cc}	259.39±3.4 ^{ba}	709.69±6.6 ^{aa}	255.2±5.3 ^{da}	723.4±0.8 ^{aa}	221.7	723.4±0.8 ^{aa}	255.2±5.3 ^{da}	723.4±0.8 ^{aa}	221.7	688.7	688.7
Baekjung	259.3±0.7 ^{aa}	722±3.5 ^{aa}	233.7±0.8 ^{cb}	647.9±7.6 ^{db}	163.4±1.3 ^{dd}	583.3±0.7 ^{bc}	221.03±5.8 ^{cc}	595.2±9.3 ^{bc}	230.6±6.4 ^{ebc}	705.9±8.4 ^{ba}	221.6	705.9±8.4 ^{ba}	230.6±6.4 ^{ebc}	705.9±8.4 ^{ba}	221.6	650.8	650.8
Alogi	261.6±1.2 ^{ab}	549.9±1.6 ^{ce}	261.5±1.1 ^{bcB}	661.7±5.8 ^{da}	185.6±0.1 ^{bd}	573.0±1.6 ^{bd}	234.17±6.9 ^{cc}	607±6.2 ^{7cc}	278.8±1.5 ^{ba}	637.1±4.0 ^{db}	244.3	637.1±4.0 ^{db}	278.8±1.5 ^{ba}	637.1±4.0 ^{db}	244.3	605.7	605.7
Pungan	234.2±2.0 ^{be}	638.2±4.7 ^{bc}	292.3±2.3 ^{cc}	672.9±1.2 ^{beB}	252.8±0.3 ^{ad}	574.2±3.4 ^{bd}	340.08±6.7 ^{aa}	682.6±2.4 ^{bb}	320.9±2.5 ^{ab}	704.4±3.5 ^{ba}	288.1	704.4±3.5 ^{ba}	320.9±2.5 ^{ab}	704.4±3.5 ^{ba}	288.1	654.5	654.5
Heughtangkong	NA	NA	267.1±1.7 ^{ba}	701.9±5.9 ^{aa}	131.0±1.4 ^{eb}	558.6±6.6 ^{cc}	265.03±9.1 ^{ba}	674.3±0.24 ^{bb}	268.0±1.3 ^{bea}	683.5±3.6 ^{bb}	232.8	683.5±3.6 ^{bb}	268.0±1.3 ^{bea}	683.5±3.6 ^{bb}	232.8	654.6	654.6
Day-wise mean value	234.9	670.0	259.0	663.9	179.2	580.3	265.6	652.0	269.6	693.3		693.3	269.6	693.3			
<i>Flavonoid content (μg QE/g)</i>																	
Daekwang	105.3±2.9 ^{aa}	458.1±23.7 ^{bc}	115.5±3.0 ^{baA}	408.7±21.4 ^{cc}	89.4±5.9 ^{bb}	604.9±12.4 ^{ba}	400±5.05 ^{dd}	461.8±21.9 ^{cc}	68.8±5.9 ^{bcC}	521.6±5.76 ^{ab}	83.81	521.6±5.76 ^{ab}	68.8±5.9 ^{bcC}	521.6±5.76 ^{ab}	83.81	491.0	491.0
Akwang	63.0±7.1 ^{cb}	730.8±25.4 ^{aa}	126.1±19.3 ^{abA}	487.4±5.6 ^{cc}	58.9±4.03 ^{bb}	624.8±5.3 ^{abb}	115.2±3.0 ^{aa}	486.5±10.6 ^{bcC}	73.3±6.7 ^{bb}	507.6±5.7 ^{ac}	87.3	507.6±5.7 ^{ac}	73.3±6.7 ^{bb}	507.6±5.7 ^{ac}	87.3	567.4	567.4
Baekjung	77.1±17 ^{bcAB}	491.2±26.1 ^{ba}	66.4±1.8 ^{cb}	457.7±2.5 ^{caB}	101.4±4.0 ^{ba}	443.1±12.63 ^{db}	36.2±2.65 ^{cc}	427.3±9.2 ^{db}	59.9±2.7 ^{bcdBC}	430.8±11.7 ^{bb}	68.2	430.8±11.7 ^{bb}	59.9±2.7 ^{bcdBC}	430.8±11.7 ^{bb}	68.2	450.0	450.0
Alogi	86.6±5.0 ^{abca}	311.7±4.2 ^{cd}	92.0±13.7 ^{baA}	589.7±8.7 ^{bb}	58.0±8.50 ^{cb}	652.1±26.1 ^{aa}	34.8±0.8 ^{db}	498.8±3.3 ^{bc}	52.0±4.2 ^{cdB}	476.1±5.9 ^{bc}	64.7	476.1±5.9 ^{bc}	52.0±4.2 ^{cdB}	476.1±5.9 ^{bc}	64.7	505.7	505.7
Pungan	92.6±2.3 ^{abc}	333.6±10.1 ^{cc}	140±12.6 ^{ba}	671.3±13.5 ^{aa}	123.7±14.9 ^{abAB}	546.4±16.4 ^{cb}	95.6±3.7 ^{bc}	549±5.1 ^{ab}	105.5±3.5 ^{abC}	532.6±9.0 ^{ab}	111.5	532.6±9.0 ^{ab}	105.5±3.5 ^{abC}	532.6±9.0 ^{ab}	111.5	526.6	526.6
Heughtangkong	NA	NA	70.6±7.7 ^{ca}	325±7.0 ^{eb}	23.1±0.6 ^{db}	323.9±5.6 ^{bb}	68.4±4.5 ^{ca}	356.8±4.0 ^{ea}	56.9±3.7 ^{cdA}	367.3±16.5 ^{da}	54.8	367.3±16.5 ^{da}	56.9±3.7 ^{cdA}	367.3±16.5 ^{da}	54.8	343.2	343.2
Day-wise mean value	84.9	465.1	101.8	490.0	75.8	532.5	65.0	463.4	69.4	472.7		472.7	69.4	472.7			

The results are expressed as mean±SE (n=3). The mean values followed by different lowercase superscripts (a–d) in same column and different uppercase superscripts (A–D) for same sprout components (cotyledon or SWC) in the same row are significantly different ($p<0.05$)

SC sprout cotyledon, SWC sprout without cotyledon, GAE gallic acid equivalent, QE quercetin equivalent, NA not available due to missing data

Table 4 Resveratrol contents of different parts of peanut sprouts from day 5 to 9

Cultivar and breeding line	D5		D6		D7		D8		D9		Cultivar and breeding line-wise mean value	
	SC	SWC	SC	SWC	SC	SWC	SC	SWC	SC	SWC	SC	SWC
Daekwang	4.1±0.01 ^{eA}	47.9±0.06 ^{dB}	2.5±0.02 ^{dB}	38.7±0.00 ^{ED}	2.0±0.02 ^{DE}	46.0±0.05 ^{EC}	2.8±0.01 ^{EC}	33.6±0.00 ^{EE}	3.2±0.02 ^{EB}	53.9±0.01 ^{aA}	2.9	44.0
Akwang	7.8±0.00 ^{bA}	48.7±0.00 ^{cA}	1.8±0.00 ^{AE}	45.8±0.13 ^{CB}	3.2±0.00 ^{EC}	38.3±0.01 ^{DE}	2.9±0.04 ^{ED}	40.1±0.07 ^{CD}	4.5±0.02 ^{DB}	43.1±0.07 ^{BC}	4.0	43.2
Baekjung	5.4±0.01 ^{cA}	53.5±0.30 ^{bA}	2.6±0.01 ^{DD}	29.8±0.03 ^{FD}	1.4±0.90 ^{EE}	53.7±0.04 ^{aA}	4.5±0.02 ^{DB}	44.5±0.29 ^{BB}	2.9±0.01 ^{EC}	42.4±0.35 ^{BC}	3.4	44.8
Alogi	5.0±0.01 ^{DE}	42.3±0.01 ^{cA}	9.5±0.00 ^{AD}	39.8±0.03 ^{DB}	10.3±0.03 ^{AB}	38.6±0.30 ^{DC}	11.3±0.01 ^{bA}	35.4±0.01 ^{DD}	9.8±0.03 ^{BC}	27.1±0.11 ^{EE}	9.2	36.7
Pungan	7.9±0.00 ^{cC}	56.2±3.49 ^{aA}	8.1±0.04 ^{BC}	49.1±0.03 ^{AD}	8.1±0.02 ^{BC}	50.1±0.03 ^{BC}	15.1±0.03 ^{aA}	54.3±0.05 ^{AB}	11.4±0.38 ^{AB}	29.8±0.03 ^{DE}	10.1	47.9
Heugttangkong	NA	NA	4.7±0.04 ^{ED}	46.5±0.02 ^{bA}	10.3±0.02 ^{aA}	35.8±0.03 ^{EC}	7.9±0.01 ^{EB}	25.0±0.02 ^{DD}	5.6±0.01 ^{EC}	39.6±0.02 ^{CB}	7.1	36.8
Day-wise mean value	6.0	49.7	4.9	41.6	5.9	43.7	7.4	38.8	6.2	39.3		

The results are expressed as mean ± SE (n=2). The mean values followed by different lowercase superscripts (a–f) in same column and different uppercase superscripts (A–D) for same sprout components (cotyledon or SWC) in the same row are significantly different ($p<0.05$)

SC sprout cotyledon, SWC sprout without cotyledon, NA not available due to missing data

improvement in the functional, nutritional, and health-related values of the sprouts [28]. In legumes like adzuki bean, black bean, soybean, and white cowpea germination enhance phenolic contents and antioxidative activities [29]. Total phenols and flavonoids contents and antioxidant capacities in seeds and sprouts of broad bean, lupine, chickpea, lentil, fenugreek and common bean are abundantly found [30]. Sprouts of mung bean, radish, broccoli and sunflower have significant total polyphenol, flavonoid contents and antioxidant activities than their seeds [31]. Seeds and sprouts of amaranth, buckwheat, quinoa and wheat show potential rich sources of antioxidant potentials and polyphenol compounds [32].

Nutrient content of four peanut cultivars have also been reported. Pungan seeds are rich in luteolin and have good composition of fatty acids [33]. Akwang seeds contain vitamins and a high ratio of oleic and linoleic acid which is considered good fatty acid composition from health perspective [34]. Similarly, considerably high ratios of oleic to linoleic acids were also found in Baekjung (2.2) and Daekwang (1.9) seeds [35].

In conclusion, peanut sprouts contained significantly high amount of functional compounds compared to the seeds. Sprout yield was significantly high ($p < 0.05$) for Pungan followed by Alogi from day 5 through 9. However, the functional compounds in the sprouts significantly varied with genotype, sprout part, and age of sprouts. Taken together, the yield, functional compounds, and antioxidant potentials of the sprouts suggested that suitable time of sprout harvest was day 5–7 for Alogi and Pungan and 5–8 for Daekwang, Akwang, Baekjung, and Heugtangkong. Results of the present study provide an insight into selection of peanut cultivars and breeding lines and their harvest time based on yield, functional compound, and antioxidant potential.

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Compliance with ethical standards

Conflict of interest The authors do not declare any conflict of interest.

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