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Enhancement of yield and nutritional value of soybean sprouts by persimmon fruit powder

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Large amount of soybean sprouts has been produced for human consumption in Korea for a long time. Various techniques and production methods have been implied to enhance the quality and yield of soybean sprouts. The objective of the present study was to investigate the effect of persimmon fruit powder treatment on yield and nutritional value of soybean sprouts. The sprout yield was increased by 16% with the addition of 5% (w/v) persimmon fruit powder during seed soaking. Vitamin C and polyphenol content were significantly (p<0.05) increased. Similarly, essential as well as total amino acid content were also enhanced. However, the moisture content and DPPH radical scavenging potential of soybean sprout were not significantly affected. On the other hand, the mineral elements especially potassium and calcium content were reduced with the application of persimmon fruit powder. The results of the present study suggest that addition of persimmon fruit powder could improve the yield, vitamin C and amino acid content, and antioxidant potential of soybean sprouts.

Key words: Persimmon fruit powder, nutritional value, soybean sprout, yield.

INTRODUCTION

Soybean is one of the important crops that has been included in Asian cuisine for centuries and is suggested to be included in Western diets because of their beneficial health effect (Sgarbieri, 1989). Germination has been proven to be one of the inexpensive and effective technologies to improve its nutritional potential (Paucar-Menacho et al., 2010) and reduce the effects of antinutritional factors such as lectins and enzyme inhibitors present in the seeds (Bau et al., 1997). Reports show that certain undesirable constituents, such as trypsin, chymotrypsin, lipoxygenase activity, phytic acid and oligosaccharides could be eliminated or reduced during germination in soybeans (Shi et al., 2010; Quinhone and Ida, 2015). In addition, the amounts of

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other constituents like vitamins, phytosterols, tocopherols and isoflavones increase (Shi et al., 2010).

Soybean sprouts have widely been consumed as an important vegetable in Korea for a long time. Huge amount of soybean sprouts is produced in Korea for human consumption (Hwang et al., 2004). Simple technology and considerably short time requirement are other advantages of soybean sprout production. Availability of functional foods in soybean sprouts is another reason for its high demand (Kim et al., 2004).

Germination process improves the nutritive value, texture and organoleptic characteristics of legumes (Frias et al., 2005; Granito et al., 2005); decreases undesirable anti-nutritional factors; and increases antioxidant potentials (Vidal-Valverde et al., 2002; Doblado et al., 2007). Different studies have been conducted investigating the effect of seed treatments and cultivation techniques that could enhance the yield and quality of soybean sprouts. Microbial safety was studied after exposing soybean seeds and sprouts to gamma radiation (Yun et al., 2013); biofortified soybean sprouts having enriched zinc content was produced with application of zinc sulphate solution (Zou et al., 2014); various light treatments were imposed to sprouts (Lee et al., 2007); influence of bacterial strains was investigated for their effect on bioactive contents and antioxidant activity of soybean sprouts (Algar et al., 2013); increased yield and inhibited rot of the soybean sprouts was found when watering the sprouts with grapefruit seed extract, chitosan and phosphate buffer (Choi et al., 2000) and *ginseng* extract improved the quality of soybean sprouts (Choi et al., 2003). Research on impact of persimmon fruit powder treatment on soybean sprouts has not been found so far although persimmon is rich in different nutrients and phytochemicals (Ebert and Gross, 1985; Gorinstein, 1999; Celik and Ercisli, 2007; Del Bubba et al., 2009). Since the persimmons fruits contain numerous nutraceutical properties, the objective of this work was to analyze the influence of persimmon fruit powder on yield and nutritional value of soybean sprouts.

MATERIALS AND METHODS

Soybean seed and persimmon powder

Soybean (*Glycine max* L.) seeds of cultivar Sowon with 12 g of 100-seed weight were purchased from a local market in Deagu, Korea. The soybean seeds were cleaned and kept into polyethylene containers and stored at 4°C until analysis. The freeze-dried persimmon fruits cv. Sangjudungsi were ground into powder (Speed Rotor Mill, Model KT-02A) and passed through a 200-mesh sieve.

Cultivation of soybean sprouts

One kilogram of intact seeds was thoroughly washed with tap water and excess water was drained out. The seeds were treated by soaking into water containing different amount of persimmon fruit powder. The treatments were named as control (seeds soaked in water without persimmon powder for 6 h), PP-1 (seeds soaked in water containing 0.5% (v/w) persimmon powder for 6 h), PP-2 (seeds soaked in water containing 1% (v/w) persimmon powder for 6 h), PP-3 (seeds soaked in water containing 2.5% (v/w) persimmon powder for 6 h), and PP-4 (seeds soaked in water containing 5% (v/w) persimmon powder for 6 h). The sprouts were watered with two hoses of 1 cm diameter for 2 min every 3 h. Soybean sprouts were grown at 20±1°C for 6 days. Samples for physicochemical studies were prepared by freeze-drying. The freeze-dried soybean sprouts were ground into powder (Speed Rotor Mill, Model KT-02A) and passed through a 100-mesh sieve. The strained samples were packed into airtight sample bottles and stored at -20°C until analysis.

Measurement of sprout yield

Total fresh weight of soybean sprouts in each batch was recorded at the end of the germination period of 6 days.

Determination of moisture and vitamin C content of soybean sprouts

Moisture and vitamin C content were determined in triplicate for each batch following the standard methods (AOAC, 1990).

Determination of mineral content of soybean sprouts

Sprout powder sample (0.5 g) was put into a cup and 15 ml of HNO_3 was added. A solution was diluted with equal volume of distilled water. Mineral concentrations were determined using inductively coupled plasma atomic emission spectrometer (ICP AES: Varian Vista, Varian Australia, Victoria, Australia) following Skujins (1998). The instrument was calibrated using known standards for each mineral. Average value of 2 replicate samples was reported.

Determination of total phenolic contents of soybean sprouts

The total phenols of the samples were estimated according to the Folin-Ciocalteau method (Singleton et al., 1999). A 50-µl sample was added to 250 µl of undiluted Folin-Ciocalteau-reagent. After 1 min, 750 µl of 20% (w/v) aqueous Na_2CO_3 were added, and the volume was made up to 5.0 ml with distilled water. The control contained all the reaction reagents except the extract. After 2 h of incubation at 25°C in dark, the absorbance was measured at 760 nm. Total phenols were determined as gallic acid equivalent (mg GAE/g extract), and the values were presented as average of triplicate analyses.

Determination of DPPH free radical scavenging potential of soybean sprouts

The 1,1-diphenyl-2-picrylhydrazol (DPPH) radical scavenging activity of sample was measured following Blois (1958) with some modifications. A 0.5 mM solution of DPPH in methanol and 0.05 M acetate buffer (pH 5.5) was prepared. An aliquot of 0.1 ml (at concentrations 0.5 to 1 mg/ml) of an antioxidant extract solution was added to 2 ml acetate buffer, 1.9 ml methanol and 1 ml DPPH solution.

Blanks contained 2 ml acetate buffer, 1.9 ml methanol and 0.1 ml cherry wine, while the control contained 2 ml acetate buffer, 1 ml DPPH and 2 ml methanol. The mixture was shaken immediately after adding DPPH and allowed to stand at room temperature in the dark, and the decrease in absorbance was measured at 517 nm

Table 1. Effect of different persimmon powders on yield and moisture and vitamin C contents of soybean sprouts cultivated for 6 days.

Sample	Total weight (g)	Moisture (%)	Vitamin C (mg/100 g)
Control	4624±62^{c} (100.0%)	86.21±0.07^{a}	16.00±0.37^{b}
PP-1	5036±69^{b} (108.9%)	86.28±0.19^{a}	16.52±0.44^{b}
PP-2	5068±32^{b} (109.6%)	87.12±1.21^{a}	16.32±0.52^{b}
PP-3	5378±55^{a} (116.3%)	85.99±3.12^{a}	17.21±0.14^{a}
PP-4	5410±48^{a} (112.3%)	84.32±3.00^{a}	17.28±0.22^{a}

Control, soybeans soaked in water for 6 h; PP-1, soybean soaked in water with 0.5% persimmon powder for 6 h; PP-2, soybeans soaked in water with 1% persimmon powder for 6 h; PP-3, soybeans soaked in water with 2.5% persimmon powder for 6 h; PP-4, soybeans soaked in water with 5% persimmon powder for 6 h. Percentage based on total weight of control. Values are expressed as mean ± standard deviation of 3 replicates. Values followed by different superscripts within a column indicate significant difference (p<0.05).

using a spectrophotometer (Shimadzu UV-1700UV, Shimadzu Scientific Instruments, Inc., Maryland, USA) after 30 min. All determinations were performed in duplicates. The inhibitory percentage of the DPPH radical by the samples was calculated as follows:

$$\text{Scavenging effect (\%)} = [A_0 - (A - A_b)/A_0] \times 100$$

Where, A_0 is the absorbance of DPPH without sample (control), A is the absorbance of sample and DPPH, and A_b is the absorbance of sample without DPPH (blank).

Determination of free amino acid content of soybean sprouts

Amino acid contents were analyzed following the procedure of Je et al. (2005) with some modifications. Soybean sprout sample (1 g) was hydrolyzed with 6 N HCl (10 ml) in a sealed-vacuum ampoule at 110°C for 24 h for amino acid composition analysis. The HCl was removed from the hydrolyzed sample on a rotary evaporator, brought to a known volume (5 ml) with 0.2 M sodium citrate buffer (pH 2.2). The sample was passed through a C-18 Sep Pak (Waters Co. Milford, USA) cartridge and filtered through a 0.22 µm membrane filter (Millipore, USA). Amino acids were determined using an automatic amino acid analyzer (Biochrom- 20, Pharacia Biotech Co., Swiss).

Statistical analysis

Data were subjected to analysis of variance (ANOVA) and differences between means at p<0.05 were analyzed using the Tukey test. The statistics package version 4.0 (Analytical Software, Tucson, AZ, USA) was used for statistical analysis.

RESULTS AND DISCUSSION

Yield and moisture and vitamin C contents of soybean sprouts

Treatment of soybean seeds with different concentration of persimmon fruit powder significantly (p<0.05) increased the soybean sprout yield (Table 1) after 6 days of germination. The highest sprout yield was found in the treatments PP-3 (5378 g) and PP-4 (5410 g) which were 16.3 and 12.3%higher than that of the control (4624 g). The higher yield of soybean sprouts with persimmon powder treatment might be due to some plant growth promoting substances present in the persimmon fruits. The results of this experiment show that yield of soybean sprouts could be improved using persimmon juice. Treatment of soybean seeds with persimmon powder did not affect the moisture content of soybean sprouts significantly (Table 1).

Vitamin C content of soybean sprout with persimmon fruit powder treatment PP-3 (17.21 mg/100 g) and PP-4 (17.28 mg/100 g) was significantly high as compared to untreated control (16 mg/100 g) and PP-1 and PP-2 samples (Table 1). The reason for higher vitamin C content in the persimmon fruit treated soybean sprouts was not well understood.

DPPH radical scavenging activities and total phenolic contents of soybean sprouts

DPPH radical scavenging capacity of soybean sprouts with persimmon fruit powder treatment was not significantly different; however, total polyphenol was significantly (p<0.05) high as compared to that of the untreated control (Table 2). The amount of polyphenol content of soybean sprout was found to be increased with the increased amount of persimmon powder, with the lowest value for PP-1 (338 µg GAE/g) and the highest for PP-4 (359.72 µg GAE/g). The higher polyphenol content of persimmon fruit powder treated soybean sprouts might be due to the polyphenols present in the persimmon fruits (Jang et al., 2010, 2011) as the application of zinc sulphate solution enriched the soybean sprouts with zinc content (Zou et al., 2014). Phenolic compounds are considered to possess antioxidant properties of foods, crops, vegetables and natural plants (Rice-Evans et al.,

Table 2. Effect of different persimmon powders on DPPH radical scavenging activities and total phenol contents of soybean sprouts cultivated for 6 days.

Sample	DPPH(% Inhibition)	Total phenol content (μg GAE/g of sample)
Control	96.66±1.31[a]	329.19±3.17[d]
PP-1	96.63±1.01[a]	338.36±4.21[c]
PP-2	96.65±0.98[a]	347.47±4.92[bc]
PP-3	96.00±1.21[a]	354.42±6.31[ab]
PP-4	96.10±1.80[a]	359.72±5.00[a]

Control, soybeans soaked in water for 6 h; PP-1, soybean soaked in water with 0.5% persimmon powder for 6 h; PP-2, soybeans soaked in water with 1% persimmon powder for 6 h; PP-3, soybeans soaked in water with 2.5% persimmon powder for 6 h; PP-4, soybeans soaked in water with 5% persimmon powder for 6 h. GAE, Gallic acid equivalents. Values are expressed as mean ± standard deviation of 3 replicates. Values followed by different superscripts within a column indicate significant difference ($p<0.05$).

1995; Maksimovic et al., 2005). Therefore, the total polyphenol content may contribute significantly to the antioxidant potential in the soybean sprouts.

Amino acid content of soybean sprouts

There were 38 amino acids analyzed in the sprout samples out of which 8 were essential and 9 others were not detected in either sample (Table 3). The sum of essential amino acids (72.16-89.2 mg/g) as well as total amino acid contents (311.5-344.08 mg/g) in persimmon fruit powder treated soybean sprouts was higher than those in the untreated control (70.56 and 305.94 mg/g of essential and total amino acids, respectively). Among the persimmon fruit powder treated sprouts, PP-4 showed the best results in terms of amount of essential as well as total amino acids content in the sprouts. Glutamic acid was the most abundantly found amino acid in the sprout samples. The content of γ-amino-n-butyric acid (GABA) was the highest for PP-4 (19.84 mg/g) followed by PP-3 (17.06 mg/g). Amino acids GABA and glycine are associated with learning and memory, stroke and neurodegenerative diseases; mediate signals between neurons that inhibit neutral amino acids and thus relieve anxiety, sedation, anticonvulsant and muscle relaxation functions (Krogsgaard-Larsen, 1989; Mody et al., 1994; Oh and Oh, 2004). GABA rich foods are also known as brain food which has bioactive capabilities to enhance blood cholesterol and triglyceride blood pressure suppression, improved cerebral blood flow, antioxidant, diuretic, insomnia, depression and anxiety stabilizingeffect on nerves and pain (Dhakal et al., 2011). The amount of amino acids is one of the key factors in determining the nutritional qualities of fruits, vegetables and foods (Basarova and Janousek, 2000). The results of this study reveal that total amino acid content in soybean sprouts could be increased by soaking the soybean seeds in water containing persimmon juice.

Mineral contents of soybean sprouts

Potassium was the most, whereas the amount of Cu was the least abundant minerals found in the soybean sprouts. The amount of Ca, Fe, and K was found reduced in the soybean sprouts which were treated with persimmon fruit powder (Table 4). Application of 5% persimmon fruit powder slightly increased the amount of Cu, Mg, Mn, Na and Zn. Overall performance of persimmon application to increase the mineral content was not found effective. Elements, As, Pb, Cd and Hg were not detected in sprout samples. Total amount of mineral content in persimmon fruit powder treated soybean sprouts were lower than that of the untreated control. The reason for the reduced mineral content in the treated samples was not well understood.

Conclusions

This study shows that yield and nutritional values of soybean sprouts could be enhanced by soaking the seeds in water containing persimmon fruit powder. The sprout yield was increased by 16% with the addition of 5% (w/v) persimmon fruit powder during seed soaking. Vitamin C content was also significantly increased with the treatment. Similarly, total polyphenol and essential as well as total amino acid content of soybean sprouts were also increased as a result of the seed treatment. However, the mineral elements especially potassium and calcium content were significantly reduced with the application of persimmon fruit powder. This study shows that soybean seed soaking in water containing persimmon

Table 3. Free amino acid composition (mg/g of dry weight) of soybean sprouts cultivated by different persimmon powders for 6 days.

Amino acid	Sample				
	Control	PP-1	PP-2	PP-3	PP-4
Essential amino acid					
L-Threonine	13.91± 2.12^{b}	14.61± 3.10^{ab}	14.91± 1.02^{b}	17.31± 0.37^{a}	16.92± 2.20^{ab}
L-Valine	19.58± 1.02^{b}	21.01± 1.92^{b}	21.06± 1.80^{b}	25.41± 1.99^{a}	24.88± 0.31^{a}
L-Methionine	1.64± 0.02^{a}	1.60± 0.01^{a}	1.49± 0.03^{c}	1.58± 0.10^{ab}	1.56± 0.04^{bc}
L-Isoleucine	10.48± 0.10^{c}	11.10± 0.12^{b}	10.73± 0.91^{b}	13.58± 1.31^{a}	13.85± 2.00^{a}
L-Leucine	5.92± 0.02^{d}	6.03± 0.01^{c}	5.41± 0.87^{d}	7.16± 0.50^{b}	8.17± 0.03^{a}
L-Phenylalanine	17.05± 0.03^{c}	17.60± 0.07^{c}	18.08± 0.06^{b}	22.10± 1.00^{a}	21.60± 0.98^{a}
L-Lysine	0.56± 0.02^{b}	0.58± 0.01^{a}	0.48± 0.01^{c}	0.54± 0.01^{b}	0.58± 0.02^{a}
L-Histidine	1.42± 0.01^{c}	1.50± 0.01^{b}	ND	ND	1.64± 0.02^{a}
Total essential amino acid	70.56	74.03	72.16	87.68	89.2
Non-essential amino acid					
O-Phospho-L-serine	ND	ND	ND	ND	ND
Taurine	ND	ND	ND	ND	ND
O-Phospho ethanol amine	0.53± 0.01^{d}	0.66± 0.02^{c}	0.53± 0.01^{d}	0.73± 0.02^{b}	0.82± 0.01^{a}
Urea	12.94± 0.03^{b}	13.85± 0.51^{a}	12.50± 0.31^{b}	14.58± 0.71^{a}	13.45± 0.61^{ab}
L-Aspartic acid	9.70± 0.07^{b}	10.16± 1.01^{a}	8.68± 0.98^{b}	9.39± 1.31^{ab}	10.61± 1.69^{a}
L-Serine	28.45± 1.12^{b}	29.48± 2.02^{b}	29.90± 1.38^{b}	33.76± 1.30^{a}	33.19± 2.00^{a}
L-Glutamic acid	79.78± 1.87^{b}	84.06± 2.00^{a}	86.67± 1.02^{a}	84.32± 1.81^{a}	79.68± 1.90^{b}
L-Sarcosine	ND	0.11± 0.01	0.11± 0.02	0.13± 0.03	0.08± 0.05
L-α-Aminoadipic acid	3.50± 0.02^{a}	3.34± 0.05^{b}	3.18± 0.07^{c}	3.40± 0.08^{b}	3.59± 0.10^{a}
Glycine	2.22± 0.31^{a}	2.27± 0.31^{a}	2.32± 0.51^{a}	2.51± 0.50^{a}	2.45± 0.59^{a}
L-Alanine	23.31± 2.10^{a}	24.47± 3.12^{a}	24.08± 0.91^{a}	26.66± 2.31^{a}	25.38± 1.61^{a}
L-Citrulline	ND	ND	ND	ND	ND
L-α-Amino-n-butylric acid	0.98± 0.02^{c}	1.10± 0.03^{b}	1.03± 0.05^{b}	1.27± 0.01^{a}	1.25± 0.04^{a}
L-Cystine	ND	ND	ND	ND	ND
Cystathionine	0.13± 0.01	0.15± 0.01	0.14± 0.01	0.17± 0.02	ND
L-Tyrosine	1.53± 0.01^{b}	1.52± 0.02^{b}	1.19± 0.01^{d}	1.33± 0.03^{c}	1.61± 0.02^{a}
β-Alanine	1.88± 0.04^{d}	2.19± 0.02^{ab}	2.13± 0.04^{b}	2.24± 0.03^{a}	2.00± 0.02^{c}
D,L-β-Aminoisobutyric acid	0.53± 0.01^{b}	0.53± 0.31^{b}	0.46± 0.02^{c}	0.53± 0.01^{b}	0.66± 0.02^{a}
γ-Amino-n-butyric acid	14.96± 0.09^{c}	14.42± 0.08^{c}	11.86± 0.02^{d}	17.06± 0.04^{b}	19.84± 0.03^{a}
Ethanolamin	2.99± 0.02^{d}	3.27± 0.01^{b}	3.10± 0.01^{c}	3.41± 0.02^{a}	3.27± 0.02^{b}
Ammonia	2.03± 0.02^{d}	2.32± 0.02^{c}	2.05± 0.11^{d}	2.87± 0.03^{b}	3.09± 0.04^{a}
Hydroxylysine	ND	ND	ND	ND	ND
L-Ornithine	ND	ND	ND	ND	ND
1-Methyl-L-histidine	15.00± 0.07^{c}	13.44± 0.03^{e}	13.85± 0.07^{d}	15.16± 0.01^{b}	15.59± 0.03^{a}
3-Methly-L-histidine	31.87± 0.04^{c}	32.38± 0.07^{b}	32.39± 0.01^{b}	36.36± 0.06^{a}	35.27± 0.06^{a}
L-Anserine	ND	ND	ND	ND	ND
L-Carnosine	ND	ND	ND	ND	ND
L-Arginine	ND	ND	ND	ND	ND

Table 3. Contd.

Hydroxy proline	0.56± 0.06[a]	0.50± 0.03[a]	0.53± 0.06[a]	0.42± 0.01[b]	0.33± 0.03[c]
Proline	2.49± 0.01[e]	2.55± 0.02[d]	2.64± 0.01[c]	2.84± 0.02[a]	2.72± 0.02[b]
Total non-essential amino acid	235.38	242.77	239.34	259.14	254.88
Total	305.94	316.8	311.5	346.82	344.08

Control, soybeans soaked in water for 6 h; PP-1, soybean soaked in water with 0.5% persimmon powder for 6 h; PP-2, soybeans soaked in water with 1% persimmon powder for 6 h; PP-3, soybeans soaked in water with 2.5% persimmon powder for 6 h; PP-4, soybeans soaked in water with 5% persimmon powder for 6 h. ND: Not detected. Values are expressed as Mean ± standard deviation of 3 replicates. Values followed by different superscripts within a row indicate significant difference (p<0.05).

Table 4. Mineral contents (mg/kg of dry weight) of soybean sprouts cultivated by different persimmon powders for 6 days.

Element	Sample				
	Control	**PP-1**	**PP-2**	**PP-3**	**PP-4**
Ca	3,089.92± 12.12[a]	2,747.85± 20.02[d]	2,116.91± 10.20[e]	2,921.61± 6.44[c]	3,066.19± 8.99[b]
Cu	8.96± 0.04[d]	11.11± 0.03a	10.00± 0.09[c]	10.41± 0.10[b]	9.99± 0.02[c]
Fe	64.96± 5.21[a]	58.81± 6.31[ab]	62.24± 3.33[a]	54.69± 1.21[b]	56.42± 3.33[ab]
K	13,577.38± 20.31[a]	12,527.06± 18.22[d]	12,863.96± 10.33[e]	12,937.24± 11.22[b]	12,614.16± 15.00[c]
Mg	1,472.97± 9.32[c]	1,443.21± 8.20[d]	1,521.29± 9.00[a]	1,477.87± 8.77[c]	1,510.16± 5.31[b]
Mn	30.21± 0.99[a]	29.68± 2.10[a]	31.58± 0.39[a]	29.82± 1.31[a]	31.71± 1.00[a]
Na	213.19± 2.31[c]	210.82± 1.98[c]	214.13± 5.21[bc]	223.90± 1.21[a]	218.20± 1.98[b]
Zn	52.08± 1.33[b]	48.72± 2.00[c]	56.49± 1.88[b]	60.63± 2.44[a]	62.51± 1.90[a]
As	ND	ND	ND	ND	ND
Cd	ND	ND	ND	ND	ND
Hg	ND	ND	ND	ND	ND
Pb	ND	ND	ND	ND	ND
Total	18,509.67	17,077.26	16,876.60	17,716.17	17,569.34

Control, soybeans soaked in water for 6 h; PP-1, soybean soaked in water with 0.5% persimmon powder for 6 h; PP-2, soybeans soaked in water with 1% persimmon powder for 6 h; PP-3, soybeans soaked in water with 2.5% persimmon powder for 6 h; PP-4, soybeans soaked in water with 5% persimmon powder for 6 h. ND: Not detected. Values are expressed as Mean ± standard deviation of 3 replicates. Values followed by different superscripts within a row indicate significant difference (p<0.05).

fruit powder could enhance the yield, vitamin C content and antioxidative potential of soybean sprouts.

Conflict of Interests

The authors have not declared any conflict of interests.

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