Utilization of Some Fruits and Vegetables By-Products to Produce High Dietary Fiber Jam

Ahmed M. S. Hussein* Mohie M. Kamil Nefisa A. Hegazy Khaled F. Mahmoud Mona A. Ibrahim
Food Technology Department, National Research Centre, Dokki, PO box 12311, Giza, Egypt.
*E-mail of the corresponding author: a_said22220@yahoo.com

Abstract
The present study aimed to investigate the chemical composition, antioxidant activity, total phenolic compounds and β-carotene of carrot peels, apple pomace, banana peels and mandarin peels and their quality in preparing jam. Mandarin and banana peels characterized by its higher crude fiber (12.16 and 5.25%) and vitamin C (68 and 16.6 mg/100g) compared to carrot peels (3.91%) and apple pomace (3.65%). Banana peels contained higher amount of magnesium, potassium, calcium and iron compared to other peels samples. Therefore, jam of banana peels characterized by its higher content in magnesium (758 mg/100g), potassium (779 mg/100g), calcium (191 mg/100g) and iron (59.15 mg/100g). Jam of apple pomace characterized by its higher phosphorus contents (220 mg/100g) followed by jam of banana peels (138 mg/100g), mandarin peels (128 mg/100g) and carrot peels (53 mg/100g). Jam of carrot peels characterized by its higher phenolics content as gallic acid equivalent (87.4 mg/100g) followed by jams of apple pomace (82.5 mg/100g), banana peels (42.7 mg/100g) and mandarin peels (34.6 mg/100g). The same trend was observed in total flavonoids as catechen equivalent (mg CAT/100g) in jams of carrot peels, apple pomace, banana peels and mandarin peels, where they were 35.9, 30.1, 23.5 and 21.7, respectively. Furthermore, jam of carrot peels had higher antioxidant activity, where its DPPH radical, had lower DPPH based IC50 (1.8 µg/ml) while jam of apple pomace, banana peels and mandarin peels had higher DPPH based IC50 reached to 2.04, 2.21 and 3.34 µg/ml, respectively. The same trend was observed for the β-carotene radical in tested jam samples. Hunter color parameter showed that jam of mandarin peels had highest lightness (L* = 39.8), followed by jam of carrot peels (29.46), apple pomace (18.27) and banana peels (15.19). Therefore, jam of banana peels was darker than other tested peels samples. Sensory evaluation showed that jam of apple pomace characterized by its higher taste and odor, followed by jam of mandarin peels, banana peels and carrot peels. Color of tested jam of carrot, banana or mandarin peels was darker than apple pomace jam. Also, jam of apple pomace gave higher scores in appearance and overall acceptability.
Keywords: Jam – Peels – antioxidant activity – Total phenolics– Total Flavonoids

Introduction

One of the major problems challenging the food industry is how to make full utilization of the waste material. Citrus juice is one of the most abundant products with vast amount of waste (rind) which could be a potential source of functional dietary fiber for food applications. Consumption of dietary fiber plays an important role in the prevention of illnesses such as constipation, reduction in the risk of colorectal cancer (Sabanis *et al*., 2009) and hypercholesterolemia (Rupasinghe *et al*., 2008), inhibition of cyclooxygenase and lipooxygenase which are related to prevention of thrombosis, atherosclerosis and carceinogenesis (Larrauri *et al*., 1996). The presence of bioactive compounds like flavonoids, with their antioxidant properties may make citrus dietary fiber more beneficial than fibers from other sources (Lario *et al*., 2004).

Banana is used fresh or processed into many products such as juice, jams, chips, puree/pulp, powder, biscuits etc. Significant quantities of banana peels, equivalent to 40% of the total weight of fresh banana, are generated as a waste product in industries producing banana based products (Tchobanoglous *et al*, 1993). Banana peel is a rich source of total dietary fiber (43.2-49.7%), starch (3%), crude protein (6-9%), crude fat (3.8-11%). Banana peel characterized by its poly unsaturated fatty acids (linoleic acid and α-linolenic acid), essential amino acids (leucine, valine, phenylalanine and threonine), and micronutrients (K, P, Ca, Mg). Banana peel dietary fibres is a good source of lignin (6-12%), pectin (10-21%), cellulose (7.6-9.6%), hemicelluloses (6.4-9.4%) and galactouroninc acid (Emaga *et al*., 2007 and 2008). Moreover, Shyamala and Jamuna (2011) stated that banana peel had good antioxidant components and activity, where the polyphenols of three varieties were in the range of 200-850 mg equivalent of tannic acid/100g and free radical scavenging activity (90-62%).

Apple pomace is produced as a by-product of the juice factories and currently it is either used for animal feeding or is disposed as an industrial waste. Apple pomace could be used to produce pectin. Also, Apple pomace is the main by-product of apple cider and juice processing industries and accounts for about 25% of the original fruit mass at 85% (Sun *et al*., 2007). Apple pomace typically contains 66.4–78.2 % moisture and 9.5–22.0% carbohydrates (Sun *et al*., 2007). In view of the antioxidant property of apple pomace, Sudha *et al* (2007) stated that, it would play an important role in prevention diseases, where they found that, apple pomace is a good source of dietary fiber and polyphenols.

Jam is a fruit preserve with a stable shelf-life that depends on high sugar content (68-72%) combined with the fruit acidity that prevents microbial invasion and growth. Jam is a complex product that requires precise balance between sugar level, acidity and pectin content of fruit boiled together to produce a gel on cooling (Egan *et al*, 1981).

This study aimed to prepare and evaluate the physicochemical and sensory properties of jam that produced from carrot peels; apple pomace; banana peels and mandarin peels, where such products could be contain higher fibers and polyphenols.

Materials and Methods

Materials

Carrot peels, apple pomace, banana peels and mandarin peels were soaked for 3 min and washed in running tap water, then minced. Jam was prepared separately from each fruit peels sample using the open pan kettle method as described by Garcıa-Martınez *et al* (2002). The formula consisted of fruit peels (1 Kg), sugar (1 Kg), and pectin (8 g). The prepared fruit peels and 500 g sugar were placed in a cooker and mixed well. The mixture was cooked under continuous stirring for 15 minutes during which the remaining sugar was added. A hand refractometer (ATAGO, Japan) was used to determine the °Brix. A refractmeter reading indicating the attainment of 68 °Brix was the point at which the concentration was stopped. Citric acid was added to adjust the pH to 3.2. Then the mixture was cooked until the total soluble solids reached 67 Brix. After that, the heat was turned off and the Jam was cooled to 87°C, filled in sterilized dry jars, labeled and stored at room temperature.

Methods

Physicochemical Analysis

Moisture, protein, fat, fiber, ash, total sugars, reducing sugars and total solids contents of the samples were determined according to the methods of AOAC (1995). Non reducing sugars were determined by difference between total sugar and reducing sugar.

Total soluble solids (TSS) were determined using a Hand refractometer (ATAGO, Japan) and expressed as Brix value. Acidity was measured according to the method of AOAC (1995) and expressed as % citric acid. Brix/acid ratio was calculated by dividing the total soluble solids on the total acidity values for each sample. The pH was measured using Hanna pH-meter HI 9021 m Germany. Also, vitamin C content was determined according to AOAC (1995) using 2, 6 di-chlorophenol endo phenol. Viscosity was measured using HAAKE viscometers (Haake, Mess-Technik Gmbhu. Co., Germany), thermostatic bath was used to control working temperature within 25°C. Viscosity result was determined in centipoise (cP) unit according to the method of Ibarz *et al*. (1994).

Color determination

Color parameters (L*, a*, and b*) of jam samples were determined using a spectro-colorimeter (Tristimulus Colour Machine) with the CIE lab colour scale (Hunter, Lab Scan XE - Reston VA, USA) in the reflection mode. The instrument was standardized with white tile of Hunter Lab Colour Standard (LX No.16379): X= 72.26, Y= 81.94 and Z= 88.14 (L*= 92.46; a*= -0.86; b*= -0.16) (Sapers & Douglas, 1987).

Total phenolics and Flavonoids contents

Total phenolics content of jam samples were determined using the method of Folin–Ciocalteu (Singleton *et al*., 1999). Results were expressed as gallic acid equivalent (mg GAE/g dry weight). Flavonoids contents of jam samples were determined using $AlCl_3$ method (Lamaison and Carnat, 1990); and expressed as catachine equivalents (mg CAT/g fruit dry weight).

Antioxidant activity

Antioxidant activity was determined using DPPH radical-scavenging assay and β-carotene-linoleic acid bleaching assay as reported by Grzegorczyk *et al*. (2007) and Matthus *et al*. (2002), respectively.

The free radical scavenging (DPPH)

DPPH radical-scavenging assay was carried out, as previously reported by Grzegorczyk *et al*. (2007). Various concentrations of ethanol and ethanol extracts of tested samples (50, 100, 150, and 200μg/ml) were added to 4 ml of 0.1mM DPPH solution in methanol and the reaction mixture was shaken vigorously. After incubation for 30 min at room temperature the absorbance was recorded at 517nm. TBHQ used as a reference in the same concentration range as the test extract. A control solution, without a tested compound, was prepared in the same manner as the assay mixture. All the analyses were done in triplicate. The degree of decolorization indicates the radical-scavenging efficiency of the extract. The antioxidant activity of tested samples was calculated as an inhibitory effect (I %) of the DPPH radical formation as follows:

Inhibition % = $100 \times A517_{(control)} - A\,517_{(sample)} / A\,517_{(control)}$

The EC_{50} value was defined as the concentration (in µg/ml) of the compound required to scavenge the DPPH radical by 50%.

β-Carotene-Linoleic Acid Bleaching Assay

The antioxidant activity was performed by slight modifications of the procedure described by Matthus *et al.* (2002). Briefly, 0.5 mg *β*-carotene was dissolved in 1 ml of chloroform, 400µl linoleic acid and 200 mg Tween 80 was added. Chloroform was removed by rotary vacuum evaporator and 100 ml distilled water saturated with oxygen were added with vigorous shaking. 2.5 ml of this reaction mixture dispensed into test tubes and 350 µl portion (1 mg/ml) of the extracts were added. The absorbance was measured at 490 nm immediately. The reaction mixture was incubated at 50ºC for 2 hrs and the absorbance was measured again. The same procedure was repeated with synthetic antioxidant (TBHQ) and a blank. Inhibition ratio of linoleic acid oxidation was calculated for tested sample and synthetic antioxidants.

Sensory evaluation

Sensory evaluation of jam samples was carried out through evaluating taste, odor, color, mouth feel, appearance and overall acceptability as described by Hussein and Shedeed (2011).

Statistical analysis

Statistical analysis of all tested samples was carried out using SPSS program to calculate standard deviations, one way analysis of variance (ANOVA), with multiple ranges least significant difference (LSD) test ($p < 0.05$).

Results and discussion

1. Chemical composition and mineral content of raw materials:

Chemical composition and minerals contents of carrot peels, apple pomace, banana peels and mandarin peels were determined and presented in Table 1. The obtained results showed that moisture content of selected peels samples ranged between 70.94-89.50%. Mandarin peels and banana peels characterized by its higher crude fiber (12.16 and 5.25%) and vitamin C (68 and 16.6 mg/100g) compared to carrot peels (3.91%) and apple pomace (3.65%). Also, higher protein content was found in mandarin peels (4.16%) and apple pomace (3.68%) compared to carrot peels (0.79%) and banana peels (0.82%). These results in agreement with Essien *et al*.,2005, . Ganai *et al*. (2006), Emaga *et al*.,2007, Shyamala & Jamuna (2010) Rababah *et al*., 2011and Gazalli *et al*.,(2013).

Table 1 summarized also the minerals contents (mg/100g) of the tested peels samples. Banana peels characterized by its higher content in magnesium (762), potassium (781), calcium (192) and iron (61.10) compared to other peels samples. Also, Apple pomace characterized with its higher phosphorus contents (250 mg/100g) compared to other peels samples. The obtained minerals contents of banana peels agreed with those found by Shyamala and Jamuna (2011).

Table 1: Some chemical composition and minerals contents of carrot, apples, banana and mandarin peels.

Component	Carrot peels	Apple pomace	Banana peels	Mandarin peels
Moisture (%)	89.50±0.52	84.78±0.45	89.85±0.59	70.94±0.32
Protein (%)	0.79±0.01	3.68±0.09	0.82±0.04	4.16±0.11
Fat (%)	0.13±0.0	3.16±0.03	0.32±0.02	1.12±0.09
Ash (%)	1.02±0.02	0.30±0.01	1.62±0.06	0.65±0.07
Crude fiber (%)	3.91±0.09	3.65±0.02	5.25±0.14	12.16±0.03
Total sugars (%)	4.65±0.11	4.43±0.06	2.14±0.01	10.97±0.09
Reducing sugars (%)	2.65±0.06	3.22±0.05	1.56±0.06	8.26±0.17
Non-reducing sugars (%)	1.80±0.03	1.21±0.03	0.58±0.01	2.71±0.03
Vit.C mg/100g	4.2±0.13	13.3±0.11	16.6±0.12	68±0.72
Mineral contents (mg/100gm)				
Ca	34.0±0.09	8.25±0.11	192±2.16	113±0.52
K	240±1.23	63.26±0.27	781±3.12	178±0.17
P	53.0±0.22	250±0.92	145±0.17	133±0.42
Fe	2.2±0.03	37.34±0.11	61.1±0.13	1.52±0.05
Mg	75.25±0.33	6.16±0.06	762±0.11	180±0.39
Na	40±0.03	43.86±0.13	24.23±0.21	425±1.22

Data presented in Table (2) show the results of chemical composition and minerals contents of each jam sample prepared from carrot peels, apple pomace, banana peels or mandarin peels. The obtained results indicated that, moisture and total sugars contents of tested jam samples ranged between (42.22-31.67%) and (59.17-50.87%), respectively. Mandarin peels jam characterized with its higher contents of crude fiber (11.85%)

followed by jam of banana peel (5.12%), carrot peel (3.65%) and apple pomace (3.50%). Also, mandarin peels jam characterized by its higher contents of vitamin C (56.2 mg/100 g) followed by jam of banana peels (11.5 mg/100 g), apple pomace (8.2 mg/100 g) and carrot peels (2.8 mg/100 g).

Table 2 summarized also the minerals contents (mg/100g) of the investigated jam samples. The obtained results indicated that, jam of banana peels characterized by its higher content in magnesium (758), potassium (779), calcium (191) and iron (59.15) compared to other jam of carrot, apple and mandarin peels. While, jam of apple pomace characterized with its higher phosphorus contents (220) followed by jam of banana peels (138), mandarin peels (128) and carrot peels (53).

Table 2: Some chemical composition and minerals contents of jam prepared from carrot, apples, banana and mandarin peels.

Component	Jam of			
	Carrot peel	Apple pomace	Banana peel	Mandarin peel
Moisture	35.68±0.18	31.67±0.15	42.22±0.22	32.36±0.11
Protein	0.35±0.07	0.31±0.01	0.42±0.02	1.35±0.01
Fat	0.21±0.01	3.12±0.03	0.30±0.01	1.05±0.06
Ash	0.94±0.03	0.33±0.05	1.07±0.03	0.37±0.03
Crude fiber	3.65±0.05	3.50±0.09	5.12±0.17	11.85±0.07
Total sugars	59.17±0.29	52.07±0.45	50.87±0.49	53.05±0.16
Reducing sugars	42.25±0.22	40.02±0.28	41.45±0.37	42.65±0.32
Non Reducing sugars	16.92±0.11	12.05±0.12	9.42±0.08	10.40±0.09
Vit.C mg/100g	2.8±0.02	8.2±0.06	11.5±0.16	56.2±0.46
Mineral contents (mg/100gm)				
Ca	34.0±0.21	8.11±0.07	191±1.28	110±0.15
K	240±0.62	62.11±0.32	779±2.38	165±0.12
P	53.0±0.11	220 ±0.75	138±0.23	128±0.35
Fe	2.2±0.03	37.34±0.33	59.15±0.12	1.45±0.06
Mg	75.3±0.65	6.16±0.09	758±2.25	178±0.11
Na	40±0.11	43.86±0.17	22.21±0.17	418±0.22

2. Physical Properties

The physical characteristics of jams from carrot peels, apple pomace, banana peels and mandarin peels summarized in Table 3. Total soluble solids (TSS) of all tested jam samples ranged between 65.0-65.6 Brix. These values accepted with the standard TSS values of jam products which range between 65-70 Brix. The pH of jam made using carrot peels, apple pomace, banana peels and mandarin peels were 4.15, 3.91, 4.25 and 4.30. Also, acidity (% as citric acid) and TSS/acidity ratio of all jam samples ranged between (0.25-0.55) and (196.97-260.00), respectively. These results are similar to that required for jam. The Brix value and pH recorded for jam of peels confirm to values recommended for jam to hinder microbial growth and maintain keeping quality as stated by Aina and Adesina (1999). Furthermore, all studied jam samples were accepted as a jam product where its viscosity ranged between 72-75.6 cP.

Table 3: Some physical properties of jam prepared using carrot peels, apple pomace, banana peels and mandarin peels.

Component	Carrot peels	Apple pomace	Banana peels	Mandarin peels
TSS	65.00±0.35	65.60±0.22	65.00±0.35	65.00±0.35
pH	4.15±0.02	3.91±0.03	4.25±0.02	4.30±0.02
Acidity (% as citric acid)	0.33±0.001	0.55±0.042	0.25±0. 001	0.25±0. 001
TSS/ acidity Ratio	196.97±2.16	216.53 ±0.85	260.00±2.16	260.00±2.16
Viscosity (cp)	72.00±1.02	75.60±0.11	72.00±1.02	72.00±1.02

3. Total Phynolics, Total Flavonoids and antioxidant activity

Antioxidant compounds in food play an important role as a health protecting factor. Natural phenolics exert their beneficial health effects mainly through their antioxidant activity (Fang *et al*., 2002). These compounds are capable of decreasing oxygen concentration, intercepting singlet oxygen, preventing 1st—chain initiation by scavenging initial radicals such as hydroxyl radicals, binding metal ion catalysts, decomposing primary products of oxidation to non radical species and breaking chains to prevent continued hydrogen abstraction from substances (Shahidi and Naczk, 2003). Total phenolic and total flavonoids compounds were determined in jams of carrot peels, apple pomace, banana peels and mandarin peels. Table 4 showed that, the higher total phenolics content as gallic acid equivalent (GAE) mg/100g of jam was found in case of using carrot peels (87.4) followed by jams of apple pomace (82.5), banana peels (42.7) and mandarin peels (34.6). The same trend was observed in total flavonoids as catechen equivalent (mg CAT/100g) in jams of carrot peels, apple pomace, banana peels and mandarin peels, where they were 35.9, 30.1, 23.5 and 21.7, respectively.

The free radical scavenging (DPPH) action or β-carotene is known to be one of the mechanisms for measuring antioxidant activity. Table 4 shows the concentration in µg/ml of the compound required to scavenge the DPPH radical or β-carotene by 50% (IC_{50} value). For the DPPH radical, jam prepared from carrot peels had lower DPPH based IC50 (1.8 µg/ml) while jam of apple pomace, banana peels and mandarin peels had higher DPPH based IC50 reached to 2.04, 3.21 and 3.34 µg/ml, respectively. The same trend was observed for the β-carotene radical in tested jam samples. The obtained results agreed with those found by Wolfe and Liu, (2003) who stated that citrus and apple fibers have better quality due to the presence of associated bioactive compounds, such as flavonoids, polyphenols and carotenes.

Table 4: Total phenolics content (mg gallic acid/100g), total flavonoids content (mg catechin /100g) and antioxidant activity of jam prepared from carrot peels, apple pomace, banana peels and mandarin peels.

Extracts	Total Phenolic	Total Flavonoids	Antioxidant Activity	
	mg GAE/100g	mg CAT/100g	DPPH (IC_{50} µg/ml)*	β-carotene (IC_{50} µg/ml)*
Carrot peels	87.4±2.37	35.9±0.97	1.8±0.07	1.62±0.1
Apple pomace	82.5±3.43	30.1±0.75	2.04±0.12	1.89±0.3
Banana peels	42.7±1.42	23.5±0.62	3.21±0.23	3.74±0.24
Mandarin peels	34.6±1.34	21.7±0.46	3.34 ±0.18	3.85±0.26

The IC_{50} value was defined as the concentration (in µg/ml) of the compound required to scavenge the DPPH radical or β-carotene by 50%.

4. Color Quality

Data presented in Table (5) represent color attributes of carrot peels, apple pomace, banana peels and mandarin peels as well as their jam products. Color parameters of tested peels samples showed that banana peels was darker than other tested peels samples, where it had the lowest lightness (L* = 24.82), redness (a* = 3.09) and yellowness (b* = 6.64). While lightness (L*) value was maximized in mandarin peels (52.83), then slightly decreased in apple pomace and carrot peels to 50.97 and 48.71, respectively. The highest redness (a*) value was found in mandarin peels (33.61) followed by carrot peels (32.64) and apple pomace (17.3). The highest yellowness value (b*) was also found in mandarin peels (50.32) followed by carrot peels (41.37) and apple pomace (21.27). Table 5 showed also that, cooking and preparing jam caused decrease in lightness (L*), redness (a*) and yellowness (b*) of all tested samples. Jam of mandarin peels characterized with its highest lightness (L = 39.8), followed with jam of carrot peels (29.46), apple pomace (18.27) and banana peels (15.19). This result could be due to the higher polyphenolics and flavonoids compounds and their antioxidant activities in carrot peels and apple pomace as mentioned before.

Table 5: Hunter color parameter of carrot peels, apple pomace, banana peels and mandarin peels as well as their jam products.

Samples	L*	a*	b*
Carrot peels	48.71±0.16	32.64±0.03	41.37±0.02
Apple pomace	50.97±0.11	17.31±0.07	21.27±0.12
Banana peels	24.82±0.19	3.09±0.09	6.64±0.17
Mandarin peels	52.83±0.22	33.61±0.03	50.32±0.19
Jam Prepared from			
Carrot peels	29.46±0.16	19.62±0.03	31.99±0.02
Apple pomace	18.27±0.22	15.68±0.03	10.50±0.19
Banana peels	15.19±0.19	4.99±0.09	10.70±0.17
Mandarin peels	39.81±0.11	16.70±0.07	33.38±0.12

5. Sensory Properties:

Sensory Properties of jam has a great importance to measure consumer attitudes and their influence on food choice and acceptability. Therefore, jam samples of carrot peels, apple pomace, banana peels and mandarin peels were evaluated sensorial and presented in Table 6. The obtained mean panel score and statistical analysis showed that, jam of apple pomace characterized with its higher taste and odor (9.30 – 9.80), followed by jam of mandarin peels (8.25 – 8.25), banana peels (8.10 – 8.50) and carrot peels (6.60 – 7.20). Mouth feel of all tested jam samples were affected by using peels, where jam of apple pomace was 7.80 followed by mandarin peels (6.32), banana peels (6.20) and carrot peels (5.20). Color of tested jam that prepared from carrot, banana or mandarin peels was darker than apple pomace jam. Also, jam of apple pomace gave higher scores in appearance and overall acceptability.

Table (6): Sensory evaluation of jams prepared using carrot peels, apple pomace, banana peels and mandarin peels.

jam	Taste (10)	Oder (10)	Color (10)	Mouth feel (10)	Appearance (10)	Overall acceptability(10)
Carrot peels	$6.60^{c}\pm0.09$	$7.20^{c}\pm0.15$	$5.80^{c}\pm0.13$	$5.20^{c}\pm0.2$	$6.30^{c}\pm 0.09$	$6.10^{c}\pm0.33$
Apple pomace	$9.30^{a}\pm0.11$	$9.80^{a}\pm0.12$	$9.00^{a}\pm0.19$	$7.80^{a}\pm.16$	$8.90^{a}\pm0.13$	$8.80^{a}\pm0.11$
Banana peels	$8.10^{b}\pm0.13$	$8.50^{b}\pm0.17$	$7.20^{b}\pm0.07$	$6.20^{b}\pm0.08$	$7.50^{b}\pm0.21$	$7.50^{b}\pm0.17$
Mandarin peels	$8.25^{b}\pm0.12$	$8.25^{b}\pm0.14$	$7.30^{b}\pm0.08$	$6.32^{b}\pm0.11$	$7.70^{b}\pm0.15$	$7.15^{b}\pm0.10$
LSD at .05%	1.11	1.17	1.01	1.06	1.03	1.25

Conclusion

Considering chemical composition, antioxidant activity, total phenolic compounds and β-carotene of carrot peels, apple pomace, banana peels and mandarin peels jam products, it could be concluded that these by-product could be valuable and excellent source for low-priced functional food components. The results showed that these jams products characterized by its higher crude fiber, vitamin C, magnesium, potassium, phosphorus, phenolics, total flavonoids, antioxidant activity and β-carotene. Sensory evaluation showed that jam of apple pomace characterized by its higher taste and odor, followed by jam of mandarin peels, banana peels and carrot peels.

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