Utilization of mango processing industrial waste into value added products

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Abstract

Around the world, the food processing industries produce significant amounts of food wastes or byproducts each year. The industries that process plant-based foods, such as those that process fruits and vegetables, cereals and pulses, nuts and oil seeds, etc., mostly create byproducts including bran, husk, pomace, seed, peel, shell, seeds, stems, and seed coat. When these waste products are disposed of as waste or used as cattle feed, they pollute the ecosystem and lose important nutrient components. By-products from the food processing industry are a prospective source of bioactive and functional chemicals that can be used for medicinal and nutritional purposes.

Due to rising health consciousness among consumers, there is a tremendous increase in demand for novel functional foods. Functional foods are utilised to improve health quality and health maintenance while lowering health risks for conditions like cardiovascular disease, cancer, osteoporosis, obesity, diabetes, and metabolic disease. India is the world's second-largest producer of fruits and vegetables. 10% of the fruit produced worldwide comes from it. Fruit wastes are a great source of phytochemicals and antioxidants. As a result, the functional characteristics of the waste from the processing of fruit can be used. The study's goal is to create sustaining and useful food products based on by-products from Tamil Nadu's mango processing industry. This study contributes to a more efficient use of mango processing industries economically.

Key words: sustaining,phto-chemicals, Antioxidants,therapeutic

INTRODUCTION

Every year, three million tonnes of citrus fruits are produced in India. Waste from citrus fruit can be used as a variety of valuable resources and raw materials. Due to the incapacity or refusal to industrially recycle and reuse such resources, unnecessary waste is produced, depleting environmental capital (Bhalerao et al., 1989). For the majority of studies on their use, mango peels have been used as a source of pectin, which is an enhanced nutritious fibre. Beerh, Raghurmaiah, and Krishnamurthy in 1976; Tandon and Garg in 1999.

Mango peels are a substantial source of flavonoids, gallotannins, flavonol O- and xanthone C-glycosides, and benzophenone derivatives, according to studies (Berardini et al., 2005; Schieber, Berardini, & Carle, 2003). (Berardini, Carle, &Schieber, 2004). A recent test of 14 mango cultivars revealed that the flavonol O- and xanthone C-glycosides are primarily found in the peels. The Tommy Atkins cultivar offered the most potential in this regard because to the highest levels of polyphenolics and better pectin found in its peels (Berardini et al., 2005).

Recent research suggest that the fruit peels and seeds of select fruits, such as grape seeds and peels, mango seed kernels, and pomegranate peels, may have antibacterial and antioxidant properties (Kabuki et al., 2007). Peroxynitrite, substituents, and 1,1-diphenyl-2-picrylhydrazyl (Picrylhydrazyl), which have strong adsorption abilities and the potential to radical scavenge activity, are believed to be the main flavonoids responsible for the antioxidant properties of grape skin by Jacob et al. (2008).

Materials and methods

Selection of varieties

Mango peels and seed kernels are among the industrial trash that is eventually disposed of after the processed ripened mango pulps. The mango peel was gathered at ABC Industries' Krishnagiri location. For the following study experiments, peels of various sizes, hues, and maturities were utilized.

Chemicals

The Department laboratory's chemicals, reagents, and standards were seized and used. The investigation made use of analytical reagents and laboratory supplies. A combination of distilled water and purified deionized water was used to manufacture all of the standards, chemicals, and reagents. The Hi-Media and Sigma firms in India were contacted to purchase the standards and chemicals.

Physical characteristics of matured mango

We chose five mango peels at random. In order to get the average, the length, width, and weight were measured.

Drying Techniques: Mango peel **s**ample is dried using cabinet dryer at 60^0C for 3 hours for drying the sample. The method of drying differs for different samples because of differences in their structure and composition.

Powdered sample: After drying the sample of mango peel is made into a fine powder by grinding into a mixer grinder. The samples are stored in ambient temperature for further analysis

Figure 1: mango peel powder

Preparation of Herbal Tea from mango peel : The optimized mango peel powder is used for preparation of Herbal Tea

Figure 2: New product Herbal Tea

Analysis of mango peel milk shake

The mango peel milk shake was tested for physical characteristics (Viscosity, TSS (Total Soluble Solid), pH, Specific gravity, Color, Water activity), chemical characteristics (Titrable Acidity, Reducing sugars, Total sugars, Non-reducing sugars, Ascorbic acid), phytochemicals (Total Phenol and Total Anti-oxidants), proximate analysis/nutritional characteristics (Ash, Moisture, Total solids, Fat, Protein, Crude fiber)

a) Viscosity

The viscometer is used to measure the viscosity of mango peel Herbal Tea. The Brookfield viscometer (LVDV-I Prime) has four spindles (61, 62, 63, 64) and among these S 62 was selected and 100 rpm was set and the digital readings were noted. (Macdonald *et al.*, 2000)

b) Total Soluble Solids (TSS)

The digital refractometer is used to calculate the Total Soluble Solids (TSS) in the herbal tea. On the digital refractometer, one or two droplets of mango peel herbal tea were added. Degree Brix was used to express the TSS value. 2013's (Abid et al.)

c) pH

A digital pH metre was used to measure the herbal tea pH. (pH Tutor,Eutech Instruments Pvt. Ltd., Singapore) Following stabilisation, the pH value was recorded (Lee et al., 2005)

d)Specific gravity

A pycnometer is used to measure the specific gravity (Slaughter et al., 2003)

e)Colour

The hue of the mango peel milkshake was measured using a Hunter lab colour flex metre. It functions by concentrating light onto a sample and measuring the energy reflected from it throughout the full visible spectrum (Ganjloo et al., 2011)

f) Water activity

Measurements of the mango peel herbal tea aw were made using the Aqua Lab Water Activity Meter 4TE. The precise dew point temperature of the sample is measured using an infrared beam that focuses on a tiny mirror. The water activity is then determined by that dew point temperature (Jawaheer et al., 2003)

Chemical parameters

a)Titrable Acidity

Mango peel herbal tea (10 ml) was diluted with water further ,The values were then noted, and the acidity was calculated. Sangrame and others (2000)

b) sugars

The methods of calculated the reducing, non-reducing, and total sugars (Lane and Eynon et al,1923)

c) Ascorbic acid

One of the most crucial components is ascorbic acid, utilising the studies in particular dye technique, it was quantified. which was recommended by (Ranganna 1986)

Nutritional analysis

The proximate analysis was carried out for mango peel herbal tea . All the tests were carried out in triplicates test methods were as follows:

a)Ash

The ash content was measured by incinerating 1ml of sample in a crucible at 550℃ for 6 hrs. Then the crucibles was cooled in a dessicator at the room temperature and then weighed to obtain the ash content (Al-Maiman and Ahmad, 2002)

b) Moisture content

Standard techniques were used to determine the moisture content (Hsu et al., 2003)

c) Total solids

The Total solids were calculated by using the data obtained during moisture content estimation by using the formula

% Total solids =100 - % moisture content

d) Total fat

Total fat was measured using modified (Onimawo, 2002). The herbal tea (5ml) was defatted using equal volumes of n-hexane and the dissolved fat was weighed after the organic solvents had been evaporated to dryness in a hot air oven.

e) Total protein

The microkjeldahl method was used to estimate the protein content (A.O.A.C,1984)

f) Crude fiber

This was estimated by Weende's method. The crude fiber content are calculated as (Chevaux *et al.*, 2001)

g) Carbohydrates

The substances' composition was calculated using the formula below:

%Moisture + Ash + %Crude Fiber + %Crude Protein + % Fat + % Carbohydrates = 100%

Organoleptic evaluation of Mango Peel Herbal Tea

On a 9-point hedonic scale, an organoleptic evaluation of the mango peel Herbal Tea was performed using the technique of (Thongrote et al., 2016). The panel of judges gave different quality attributes, such as colour, flavour, taste, and overall acceptability, an average score that was published.

Statistical analysis

Multiple comparison using One way ANOVA had also been employed for the statistical evaluation.

RESULTS AND DISCUSSION

Proximate analysis of Developed Mango peel Herbal Tea

The laboratory of the community science college and research institute in Madurai is where the proximate analysis is done. The table below demonstrates the analysis of a sample of control, H1, H2, and H3, where H1 was combined with 10% mango peel powder, H2 with 20% mango peel powder, and H3 with 30% incorporation level.

Table 1: Proximate analysis of New product mango peel Herbal Tea

Sample	Carbohydrates(g/100g)	Moisture%	Ash (g/100g)	Fat(g/100g)	Protein(g/100g)	Crude Fiber(g/100g)
C	52.9	5.8	0.9	8.2	23.7	8.5
H1	52.9	6.1	0.9	8.8	24.3	7
H2	56.4	5.8	0.7	7.9	21.1	8.1
H3	54.7	5.5	0.8	8.1	22.6	8.3

The table above illustrates the proximate analysis of many samples, including the control sample and samples that received other treatments likeH1, H2, and H3. When compared to other treatments, H1 treatment had a higher percentage of moisture (6.1%), ASH content (0.9), fat (8.8 grammes per 100 grammes), and protein (24.3 grammes per 100 grammes).

Effect of mango peel and TSS in Mango peel Herbal Tea on physiochemical parameter

For the creation of mango peel Herbal Tea with concentration levels ranging from 10% to 30% and with various TSS, the optimal mango peel powder process treatment was used. Additionally, H1, H2, and H3 were used to investigate the physicochemical alterations and sensory acceptability of the developed mango peel herbal Tea

Table number 2: Analysis of physical parameters for developed mango peel Herbal Tea

Sample	Parameters							
	Ph	Colour			Tss %	Viscosity	SP.Gravity	Water activity
		L	A	B				
C	4.8	60.3	0.8	11.5	11.3	4.60cp	0.5	0.6
H1	4.5	62.5	0.7	11.2	11.5	6.75cp	0.6	0.7
H2	3.9	63.4	0.6	11.3	11.6	7.20cp	0.7	0.8
H3	3.7	64.4	0.5	11.5	11.8	9.00cp	0.8	0.9

The above table displays the results of the change in pH for the control sample, which was 4.8, and the H1 treatment, which was 4.5, the H2 treatment, which was 3.9, and the H3 treatment, which was 3.7. It also displays the results of the change in TSS, which was 11.3 percent for the control sample, 11.5 percent for H1, 11.6 percent for H2, and 11.8 percent for H3, respectively.

Effect of Mango peel and TSS in Mango peel Herbal Tea on sensory attributes

The 20 panellists assessed the sensory characteristics of all nine samples to determine the most effective therapies. Utilizing numerous qualities such as colour, Apperance, flavour, and taste, the sensory study was conducted utilising a 9-point Hedonic scale for three distinct levels of mago peel milk shake integration. Mango peel Herbal Tea contents were considerably greater (P 0.05). The sample H1 with the highest percentage of mango peel inclusion has better colour and is more widely accepted. This outcome was in line through the conclusions by (Chilana et al., 2015).

Table 3: Sensory analysis for strawberry vanilla mango peel milk shake
Multiple comparisons using one-way ANOVA

Mango peel –Herbal Tea				
Organoleptic Test				
Sensory characteristics	**H0**	**H1**	**H2**	**H3**
Appearance &color	7.5a	8.2b	8.1b	7.3a
Flavour	7.2a	8.5b	8c	7.1a
Consistency	7a	8.5b	8.2c	7.5d
Taste	7a	8.5b	8c	7.5d
Overall acceptability	7a	**8.5b**	8c	7.5d

The means that differ by a substantial amount (p 0.05) within a row are those with distinct letters.

Conclusions

It is possible to make drinks from mango peel that are palatable and have a long shelf life by incorporating different concentrations of the comparisons and conclusions of the study. The mango peel Herbal Tea generated products that were pleasant to the eye and received high marks during the storage and sensory periods. The mango peel Herbal Tea also has the added advantage of improving in flavour over time. This method can ease the problems faced by business owners by reducing deterioration rates, preventing fruit waste, such as in the market, and successfully using sparse, excellent nutritional fruits inside the form of refreshments while also preserving micronutrients and phytopharmaceutical qualities of fruits for a number of years. The study showed that mango peel might be used to make healthy beverages for commercial use.

REFRENCES

Abdalla, A., Darwish, S., Ayad, E., & El-Hamahmy, R. (2007a). Egyptian mango byproduct 1. Compositional quality of mango seed kernel. Food Chemistry, 103(4), 1134e1140.

Abdalla, A., Darwish, S., Ayad, E., & El-Hamahmy, R. (2007b). Egyptian mango byproduct 2: Antioxidant and antimicrobial activities of extract and oil from mango seed kernel. Food Chemistry, 103(4), 1141e1152.

Abdel, M., Ashoush, I., & Nessrien, M. (2012). Characteristics of mango seed kernel butter and its effects on quality attributes of muffins. Food Science and Technology, 9(2), 1e9.

Abdullah, H., Mohammed, A., & Abdullah, R. (2014). Cytotoxic effects of Mangifera indica L. kernel extract on human breast cancer (MCF-7 and MDA-MB-231 cell lines) and bioactive constituents in the crude extract. BMC Complementary and Alternative Medicine, 14, 19

Ajila, C.M., Aalami, M., Leelavathi, K. and Prasada Rao, U.J.S. 2010. Mango peel powder: A potential source of antioxidant and dietary fiber in macaroni preparations. Innov. Food Sci. Emerg. Technol. 11: 219-224.

Ajila, C.M., Leelavathi, K. and Prasada Rao, U.J.S. 2008. Improvement of dietary fiber content and antioxidant properties in soft dough biscuit with the incorporation of mango peel powder. J. Cereal Sci. 48: 319-326.

AOAC. 1995. Official methods of analysis. Association of official analytical chemists of the 16th Ed. International, Washington, D.C., U.S.A.

Ajila, C. M.; Naidu, K. A.; Bhat, S. G. and Prasada Rao, U. J. S. (2007). Bioactive compounds and antioxidant potential of mango peel extract. Food Chemistry, 105: 982–988.

Ajila, C.M.; Aalami, M.; Leelavathi, K. and Prasada Rao, U.J.S. (2010). Mango peel powder: A potential source of antioxidant and dietary fiber in macaroni preparations. Innovative Food Science and Emerging Technologies, 11: 219–224

Ashoush, I.S. and Gadallah M.G.E. 2011. Utilization of Mango peels and seed kernels powders as sources of phytochemicals in biscuit. World J. Dairy Food Sci. 6(1): 35-42.

Bloor, S. 2001. Overview of methods for analysis and identification of flavonoids, Meth. Enzymol. 335: 3-14.

Branen, A.L. 1975. Toxicology and biochemistry of butylated hydroxyanisol and butylated hydroxytoluene. J. Am. Oil Chem. Soc. 5: 59-63.

Da Silva, A., & Jorge, N. (2014). Bioactive compounds of the lipid fractions of agroindustrial waste. Food Research International, 66, 493e500.

Dhingra, S., & Kapoor, A. (1985). Nutritive value of mango seed kernel. Nutritive Value of Mango Seed Kernel, 36(8), 752e756.

Dina, A., Nassima, C., Meriem, B., & Karima, A. (2009). Antioxidant capacity and phenol content of selected Algerian medicinal plants. Food Chemistry, 112, 303e309.

Dorta, E., Gonz alez, M., Lobo, M. G., Sanchez-Moreno, C., & de Ancos, B. (2014). Screening of phenolic compounds in by-product extracts from mangoes (Mangifera indica L.) by HPLC-ESI-QTOF-MS and multivariate analysis for use as a food ingredient. Food Research International, 57, 51e60.

Dorta, E., Lobo, G., & Gonz alez, M. (2012a). Using drying treatments to stabilise mango peel and seed: Effect on antioxidant activity. Food Science and Technology, 45(2), 261e268.

Dorta, E., Lobo, M. G., & Gonzalez, M. (2012b). Reutilization of mango byproducts: Study of the effect of extraction solvent and temperature on their antioxidant properties. Journal of Food Science, 77(1), C80eC88.

Dorta, E., Lobo, G., & Gonz alez, M. (2013). Optimization of factors affecting extraction of antioxidants from mango seed. Food and Bioprocess Technology, 6(4), 1067e1081.

Dhingra, S. and Kapoor, A. C. 1985. Nutritive value of mango seed kernel. Journal of the Science of Food and Agriculture 6: 752-756

DuBois, M., Gilles, K.A., Hamilton, J.K., Reberts, P.A. and Smith F. 1956. Colorimetric method for determination of sugars and related substances. Anal. Chem. 28(3): 350-356.

El-Soukkary, F.A.H.; EL-Sahn, M.A. and Mohamed, H.M.A. (2000). Physico-chemical and nutritional evaluation of mango seed kernel and its utilization for pan bread supplementation. Zagazig J. Agric. and Res., 27: 1319-1342.

Hooda, S. and Jood, S. 2005. Organoleptic and nutritional evaluation of wheat biscuits supplemented with untreated and treated fenugreek flour. Food Chem. 90: 427-435.

Hemavathy, J., Prabhakar, J., & Sen, D. (1988). Drying and storage behaviour of mango (Mangifera indica) and Composition of kernel fat. Asian Food Journal, 4(2), 59e63.

Ibarra, I., Ramos, P., Hern andez, C., & Jacobo, D. (2015). Effects of postharvest ripening on the nutraceutical and physicochemical properties of mango (Mangifera indica L. cv Keitt). Postharvest Biology and Technology, 103(0), 45e54.

Jahurul, M., Zaidul, I., Ghafoor, K., Al-Juhaimi, F., Nyam, K., Norulaini, N., et al. (2015). Mango (Mangifera indica L.) by-products and their valuable components: A review. Food Chemistry, 183, 173e180.

Jahurul, M., Zaidul, I., Nik, N., Sahena, F., Kamaruzzaman, B., Ghafoor, K., et al. (2014). Cocoa butter replacers from blends of mango seed fat extracted by supercritical carbon dioxide and palm stearin. Food Research International, 65, 401e406.

Jahurul, M., Zaidul, I., Norulaini, N., Sahena, F., Abedin, M., Ghafoor, K., et al. (2014). Using differential scanning calorimetry and pulse nuclear magnetic resonance to characterise the melting and crystallisation patterns of mixtures of mid-fraction palm oil and mango seed fat used to substitute cocoa butter. 103e109 in Food Research International, vol. 55.

Jahurul, M., Zaidul, I., Norulaini, N., Sahena, F., Abedin, M., Mohamed, A., et al. (2014). Hard cocoa butter replacers from mango seed fat and palm stearin. Food Chemistry, 154, 323e329.

Jahurul, M., Zaidul, I., Norulaini, N., Sahena, F., Jaffri, J., & Omar, A. (2014). Supercritical carbon dioxide extraction and studies of mango seed kernel for cocoa butter analogy fats. CyTA - Journal of Food, 12(1), 97e103.

Joyce, O.O; Latayo, B.L and Onyinye, A.C. (2014). Chemical composition and phytochemical properties of mango (mangifera indica.) seed kernel International Journal of Advanced Chemistry, 2 (2): 185-187.

Kim, H.J.Y., Moon H., Kim, D., Lee, M., Cho, H., Choi, Y.S., Kim, M.A. and Cho, S.K. 2010. Antioxidant and antiproliferative activities of mango (Mangifera indica L.) flesh and peel. Food Chem. 121: 429-436.

Khammuang, S., & Sarnthima, R. (2011). Antioxidant and antibacterial activities of selected varieties of thai mango seed extract. Pakistan Journal Pharmaceutical Science, 24(1), 37e42.

Leanpolchareanchai, J., Padois, K., Falson, F., Bavovada, R., & Pithayanukul, P. (2014). Thai mango seed kernel extract topical delivery using a microemulsion system: development, physicochemical characterization, and ex vivo skin permeation tests. 19(11), 17107–17129. Molecules

Larrauri, J.A., Ruperez, P., Borroto, B. and Saura-Calixto, F. 1996. Mango peels as a new tropical fibre: Preparation and characterization. Lebensmittel Wissenschaft Technologie. 29: 729-733.

Leelavathi, K. and Haridas Rao, P. 1993. Development of high fiber biscuits using wheat bran. J. Food Sci. Technol. 30: 187-191.

Loelillet, D. 1994. The European mango market: A promising tropical fruit. Fruit. 49: 5-9.

Maisuthisakul, P. and Gordon, M.H. 2009. Antioxidant and tyrosinase inhibitory activity of mango seed kernel by product. Food Chem. 117: 332-341.

Moharram, Y.G. and Moustafa, A.M. 1982. Utilisation of mango seed kernel (Magnifera indica) as a source of oil. Food Chem. 8(4): 269-276.

Masibo, M., & He, Q. (2009). Mango bioactive compounds and related nutraceutical propertiesda review. Food Reviews International, 25(4), 346e370.

Ma, X., Wu, H., Liu, L., Yao, Q., Wang, S., Zhan, R., et al. (2011). Polyphenolic compounds and antioxidant properties in mango fruits. Scientia Horticulturae, 129(1), 102e107.

Miki, T., Kochi, T., Eguchi, M., Kuwahara, K., Tsuruoka, H., Kurotani, K., et al. (2014). Dietary intake of minerals in relation to depressive symptoms in Japanese employees: The Furukawa nutrition and health study. Nutrition, 31(5), 686e690.

Mirabella, N., Castellani, V., & Sala, S. (2014). Current options for the valorization of food manufacturing waste: A review. Journal of Cleaner Production, 65, 28e41.

Moo, V., Moo, M., Estrada, R., Cuevas, L., Estrada, I., Ortizz, E., et al. (2014). Antioxidant compounds, antioxidant activity and phenolic content in peel from three tropical fruits from Yucatan, Mexico. Food Chemistry, 166(1), 17e22

Nunez-Selles, A.J. 2005. Antioxidant therapy: Myth or reality? J. Braz. Chem. Soc. 6(4): 699-710.

Palaniswamy, K. P., Muthukrishna, C. R. and Shanmugavelu, K. G. 1974. Physicochemical characteristics of some varieties of mango. Indian Food Packer 28 (5): 12-18.

Rimm, F.B., Ascherio, A., Giovannucci, M.D., Spiegelman, D., Stampfer, M.D. and Willett, W.C. 1996. Vegetable fruit and cereal fibre intake and risk of coronary heart disease among men. J. Am. Med. Assoc. 275: 447-451.

Schiber, A., Berardini, N. and Carle, R. 2003. Identification of flavonol and xanthol glycosides from mango peels by HPLC. J. Agri. Food Chem. 51: 5006-5011.

Singleton, V.L., Orthofer, R. and Lamuela-Raventos, R.M. 1999. Analysis of total phenols and other oxidation substrates and antioxidants by means of Folin-Ciocalteu reagent. Meth. Enzymol. 299: 152-178.

Soong, Y.Y., Barlow, P.J. and Perera, C.O. 2004. A cocktail of phytonutrients: Identification of polyphenols, phytosterols and tocopherols from mango (Mangifera indica L.) seed kernel. In IFT annual meeting, July 12-16, Las Vegas.

Solís, J., & Dur an, M. (2011). Chapter 88 e Mango (Mangifera indica L.) seed and its fats. In Nuts and seeds in health and disease prevention (pp. 741e748).

Sonwai, S., Kaphueakngam, P., & Flood, A. (2012). Blending of mango kernel fat and palm oil mid-fraction to obtain cocoa butter equivalent. Journal of Food Science and Technology, 51(10), 1e13.

Soong, Y., & Barlow, P. (2006). Quantification of gallic acid and ellagic acid from longan (Dimocarpus longan Lour.) seed and mango (Mangifera indica L.) kernel and their effects on antioxidant activity. Food Chemistry, 97, 524e530.

Tharanathan, R., Yashoda, H., & Prabha, T. (2006). Mango (Mangifera indica L.), "The King of Fruits"dAn overview. Food Reviews International, 22(2), 95e123

Van Dyk, J., Gama, R., Morrison, D., Swart, S., & Pletschke, B. (2013). Food processing waste: Problems, current management and prospects for utilisation of the lignocellulose component through enzyme synergistic degradation. Renewable and Sustainable Energy Reviews, 26, 521e531.

Veloglu, Y.S., Mazza, G.L.G. and Oomah, B.D. 1998. Antioxidant activity and total phenolics in selected fruits, vegetables and grain products. J. Agri. Food Chem. 6(10): 4113-4117.

Wu, S., Tokuda, M., Kashiwagi, A., Henmi, A., Okada, Y., Tachibana, S., et al. (2015). Evaluation of the fatty acid composition of the seeds of Mangifera indica L. and their application. Journal of Oleo Science, 484(5), 479e484.

Youssef, A. (1999). Utilization of the seed of mango processing wastes as a secondary source of oil and protein. Alexandria Journal of Agricultural Research, 44(3), 149e166.

Zein, R., El-Bagoury, A., & Kassab, H. (2005). Chemical and nutritional studies on mango see kernels. Journal of Agricultural Science, 30(6), 3285e3299