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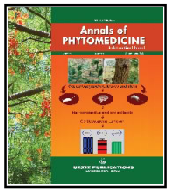

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Extraction of antioxidants from potato peels and incorporation into value-added products

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Abstract

Food processing industries are emerging rapidly and are one of the world's most significant industries. Some byproducts that are disposed of as waste are actually rich sources of bioactive compounds, and hence can be reused. In the present study, potato peels that are byproducts of various potato-based industries were chosen as they possess high natural antioxidant activity as well as nutritional value. The primary goal of the present study was to utilize the best out of waste. Solvents such as methanol and ethanol were used for extracting the antioxidants from potato peels. Total phenolic content of potato peel extracts was examined. The radical scavenging activity of 2, 2-diphenyl-1-picrylhydrazyl (DPPH) test was used to determine the antioxidant activity of the extracts. Different concentrations of extract of potato peel (1%, 2%, and 3%) were incorporated into the dough, and nachos were prepared. The criteria that were used for assessing the antioxidant activity of the extract in nachos were: peroxide value and acid value. The chemical composition of the peel was determined. Ethanol potato peel extracts were found to have 89.14% of radical scavenging activity as compared to methanol potato peel extract (67%). Thus, it was found that ethanol is a better organic solvent for extracting phenolic compounds from potato peels. It was found that 3% ethanol extract of potato peels gave better antioxidant activity as compared to others. Potato peels are nutritionally rich and have good antioxidant activity. Thus, it can be a good alternative to synthetic antioxidants in food products.

1. Introduction

Food processing industries are emerging rapidly worldwide. During the processing of raw materials, the product-specific waste accumulates unavoidably. Waste is generated by the industries during the various stages of production. Even after extraction, the residual materials still contain a variety of potentially useful components. Product-specific waste contains a high proportion of organic material. Traditionally, there are two methods of utilizing waste, *viz.*, one is animal feed and the other is used as a fertilizer (Ben-Gera and Kramer, 1969).

Considering the scarcity of existing high-quality low-cost foods, nutrient recovery from waste sources and their use as foods or feeds will help to mitigate the risk of widening the gap between global population and global food supplies (Ben-Gera and Kramer, 1969). Byproducts of such industries are mainly organic in nature and must be handled properly so as to avoid any environmental pollution (Al-Weshahy and Rao, 2012). Environment is getting affected because of the mismanagement of waste disposal (Russ and Meyer-Pittroff, 2004). Thus, optimum utilization of waste is necessary.

The fourth most important crop is potato (*Solanum tuberosum*, L.), following rice, wheat, and corn (Zhang *et al.*, 2017). Potato is known as the "king of vegetables". Potatoes have long been valued as staple starch since they add carbohydrates and calories to the diet. It contains vitamin C, iron, and vitamin B. In 2008, FAO declared "The international year of the potato" to draw attention to the global value of the potato (Uses of potato, 2008). Potato peels are produced in huge amounts because, the global consumption is shifting to value-added food products rather than fresh potatoes.

Statistically, 70-140 thousand tonnes of potato peels are being generated by the potato processing industries worldwide. It is a zero-value waste produced by these industries. Potato waste has a significant impact on environmental degradation and costs. Identifying an integrated and ecologically friendly solution for the reuse or disposal of waste is critical for food processing industries (Gebrechristos and Chen, 2018). Phenolic compounds are present in large amounts in potato peels. Phenolic compounds such as hydroxycinnamic acid derivatives and flavonoids have been found in potato peel extract (Samotyja, 2019). These compounds are used in a variety of industries, including the food, cosmetics, and pharmaceutical industries (Venkatachalam *et al.*, 2021, Pap *et al.*, 2004).

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Phenolic compounds are an important group of natural antioxidants (Pourreza, 2013). Due to their optimal structural chemistry for free radical scavenging capabilities, phenolic compounds are efficient antioxidants. Thus, the presence of highly reactive hydrogen or electron donor, ability to chelate transition metal ion, stabilization of radical, and delocalization of the unpaired electron contribute to their antioxidant activity (Rice-Evans *et al.*, 1997). Antioxidants are becoming one of the most important components in the food processing industry. It helps in inhibiting the rancidity of fat-based food products (Pokorny *et al.*, 2001). Synthetic antioxidants such as butylated hydroxyanisole (BHA), butylated hydroxytoluene (BHT), and tertiary butylhydroquinone (TBHQ) are used to overcome the oil and fat stability. However, recent research has suggested that synthetic antioxidants have harmful effects on health. Thus, food scientists show increasing interest in finding natural sources of antioxidants (Rowayshed *et al.*, 2015). Thus, the extraction of natural antioxidants from potato peels can be a good alternative to synthetic antioxidants to retard lipid oxidation and extend the shelf life of food products. Thus, it will help in solid waste management. Hence, the waste can be used in an effective way and the product will be cost-effective.

The antioxidant property of potato peel extract has been reported in some food products, *e.g.*, processed lamb meat, fish-rapeseed oil mixture, soybean oil minced horse mackerel, ground salmon, *etc*., but its use as an antioxidant in deep-fried food products like nachos has not yet been studied. Also, no studies have been done using the Kufri Bahar variety which is a very important variety in various parts of India. Thus, the overall objective of this study was to utilize the potato peels as a natural antioxidant source and incorporate them into value-added products and check their effectiveness in the stability of oil in nachos.

2. Materials and Methods

2.1 Materials

Potato peels (*Solanum tuberosum*,L.; variety Kufri Bahar) were collected from a local market. Whole corn flour, refined corn flour, refined flour, whole wheat flour, red chili powder, turmeric powder, salt, and oil to fry were used to prepare nachos. For the evaluation of various parameters in potato peels, all of the chemicals considered were of analytical grade.

2.2 Methods

2.2.1 Chemical composition

The chemical composition (moisture, ash, total carbohydrates, protein, and fat) of potato peels was determined by using the method reported (AOAC, 1999; Raghuramulu *et al*., 2003; Dubois *et al*., 1956; Neilsen Suzenne, 2010). All the tests were repeated three times in triplicate and the data shown is as mean ± SD. Calcium, iron, and phosphorus content were also determined using the Clark-Collip's, Ramsay's method, and Fiske-Subbarow methods, respectively (Varley, 1976; Yuen and Pollard, 1951).

2.2.2 Preparation of potato peel extract

A dehydrator was used to dry potato peels. 50 g of fresh potato peels were washed and dehydrated for 6-7 h at 50°C. A fine powder was made from the dried sample. Two grams of dried ground material were extracted using the orbital shaker at room temperature at 120 rpm with 20 ml of organic solvents (70% ethanol, 70% methanol, and 70% acetone). Whatman No. 1 filter paper was used to filter the extracted materials. A rotary evaporator was used to collect and concentrate the supernatant at temperatures below 45°C. The per cent yield of the natural antioxidant under research was calculated using the extracts obtained following evaporation of the organic solvent (Dubey *et al.*, 2020; Rowayshed, 2015).

2.2.3 Total phenolic content determination

The total phenolic content was assessed in all three extracts. In a 10 ml test tube, 50 µl of each diluted extract was pipette out and mixed with 1950 µl water. One milliliter of Folin-Ciocalteu reagent was added to the test tube and shaken vigorously. 5 ml sodium carbonate solution (20%) was added. A total volume of 10 ml was made and thoroughly mixed. The absorbance was measured at 735 nm after 20 min. A blank cuvette was used to zero the spectrophotometer. The gallic acid standard curve was used to determine the phenolic content of the extracts. The results were represented as gallic acid equivalents (GAE) per 100 g of dried potato peels.

2.2.4 Radical scavenging activity (RSA %) assay

2.2.4.1 Determination of antioxidants activity

The free radical scavenging potential of the potato peel extracts was assessed using the DPPH assay (Baskaran and Subash, 2021; Gahlot *et al.*, 2021; Kavalan *et al*., 2020). 2.9 ml of 0.1 mM DPPH prepared in methanol was added to 40 µl of sample solution and the tubes were stored in dark for 30 min. The absorbance was measured at 517 nm. Methanol was used as a control. The percentage inhibition of the DPPH radical was estimated using the following equation:

$$\% \text{ Scavenging} = 100 - [(As/A0) \times 100]$$

where

As was the sample's absorbance and A0 was the control's absorbance.

Control: 2.9 ml DPPH solution with 40 µl methanol.

2.2.5 Application of potato peels extract in nachos

2.2.5.1 Preparation of nachos

Different concentrations of antioxidant extract (0, 1%, 2%, and 3%) of potato peels were added to nachos. Control was prepared without the addition of natural antioxidant extract.

The nachos were prepared using the following ingredients, *i.e*., 30 g whole corn flour, 25 g refined flour, 15 g refined corn flour, 10 g whole wheat flour, 5 g carom seeds, 5 g red chilli powder, 2 g turmeric powder, salt as per taste and oil for frying.

2.2.5.2 Processing of nachos

The above-mentioned ingredients were mixed together. In water, different concentrations of methanol and potato peel ethanol extract were prepared. This water was used for the preparation of dough for the nachos. Thus, in total 7 variants of nachos consisting of control, ethanol extract of potato peel (1%, 2%, 3%), and methanol extract of potato peels (1%, 2%, 3%) were prepared. The dough was sheeted to a thickness of 2-3 mm and cut into a triangular form using a knife and was deep fried in the oil at 85-195°C for 5-6 min. Nachos were fried and cooled to room temperature before being

packaged in polythene pouches then sealed, and stored until further testing and analysis.

Table 1: Chemical composition of potato peels

Parameter	Value/100 g fresh weight
Moisture (g)	15.4
Ash (g)	0.9
Total carbohydrate (g)	11.1
Protein (g)	1.45
Fat (g)	1.65
Calcium (mg)	0.15
Phosphorus (mg)	47.2

2.2.5.3 Sensory evaluation

Sensory evaluations of nachos were conducted as per the method reported (Lalas and Dourtoglou, 2003). Sensory evaluation was done in order to determine the overall acceptability of the nachos which were prepared using the different concentrations of potato peel extract. 30 semi-trained panelists were selected for evaluating the nachos on a 9-point hedonic scale. Semi-trained panelists were the students who were pursuing Masters in Food Processing and Preservation. Sensory scores of different attributes *e.g.*, appearance, colour, flavour, texture, mouth feel, odour, and after taste was recorded.

2.2.5.4 Chemical analysis of nachos

The peroxide value and acid value of nachos were measured every five days for a total of 35 days of storage at room temperature. The Soxhlet apparatus was used to remove the fat from nachos. Oil extracted was used for the estimation of peroxide value and free fatty acid.

2.2.5.5 Determination of peroxide value

In oil samples, the peroxide value was determined using the volumetric estimation method. In 30 ml of organic solvent, 5 g of sample (oil) was dissolved (3:1- glacial acetic acid: chloroform). 30 ml distilled water and 0.5 ml saturated KI solution were added. 0.01 N sodium thiosulphate was used to titrate the solution until it became pale yellow. 1 ml of the starch solution was added to the flask as an indicator and then it was titrated until the blue hue faded (Neilsen Suzenne, 2010).

Peroxide value = (S × N)/sample weight (g) ×1000

where, S = for sample titration (ml).

N = sodium thiosulphate normality

2.2.5.6 Determination of free fatty acid

In oil samples, the acid value was estimated using the volumetric estimation method. 2 ml of the aliquot was dissolved in 10 ml of neutral solvent (alcohol: ether mixture) and was titrated against 0.1 N KOH using phenolphthalein as the indicator (Neilsen Suzenne, 2010).

$$\text{Acid value} = \frac{\text{Titre value} \times \text{Normality of KOH} \times \text{Molecular weight of KOH}}{\text{Weight of the sample}}$$

3. Results

3.1 Potato peel composition (variety: Kufri Bahar)

The composition of potato peels (Kufri Bahar) was determined. Table 1 represents the chemical composition of potato peels (Kufri Bahar). Potato peels contains 15.4% moisture, 0.9 g ash, 11.1 g total carbohydrate, 1.45 g protein, 1.65 g fat, 0.15 mg calcium and 47.2 mg phosphorus.

3.2 Total phenolic content

The concentration of phenolic content in methanol and ethanol extracts of potato peels was determined and was expressed in gallic acid equivalent (GAE) as mg/100 g of the dry weight of the plant materials. A calibration curve was made (Figure 1) and the content of phenolics in potato peels was calculated. Total phenolic content of potato peels extracts was ranging from 52.5 ± 0.51 to 102.66 ± 0.26 (Table 2).

Table 2: Total phenolic content in potato peels

Sample	Solvent	Total phenolic content [mg GAE (gallic acid equivalent)/ 100 g of dry weight of potato peel]
Potato peels	Methanol	52.5 ± 0.51
	Ethanol	102.66 ± 0.26

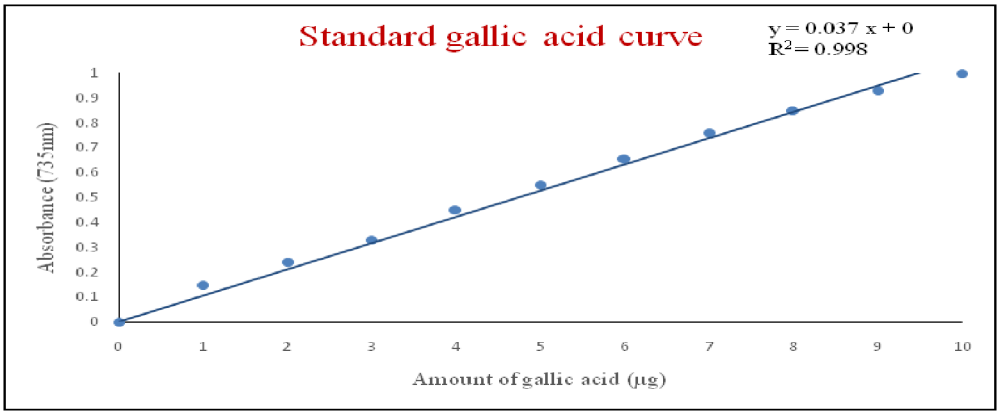

Figure 1: Gallic acid calibration curve for determining total phenolic content in potato peel extract.

3.3 Antioxidant activity using DPPH radical scavenging activity

The antioxidant potential of potato peels extract was determined by using 2, 2-diphenyl-1-picrylhydrazyl (DPPH) radical scavenging activity and is presented in Table 3. DPPH assay was performed three times in triplicates. The mean of all the readings is given in Table 3. DPPH activity was found to be more in ethanol extract as compared to methanol extract.

Table 3: Antioxidant activity (AA) of potato peel extract

Tested sample	Methanol extract (AA %)	Ethanol extract (AA %)
Potato peels	82.70 ± 0.03	89.73 ± 0.02

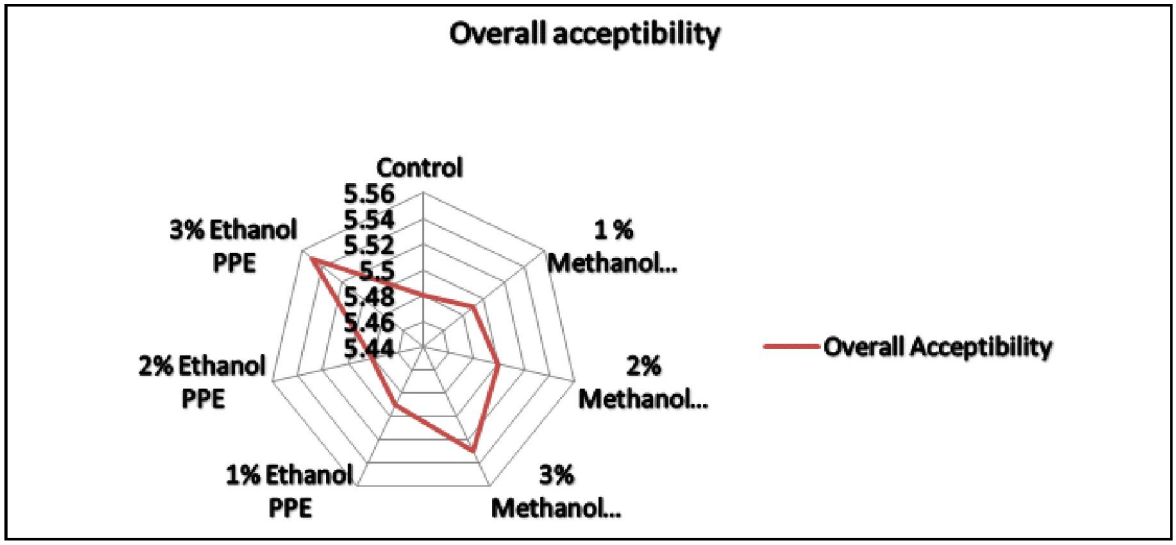

Figure 2: Radar diagram depicting the overall acceptability of the nachos.

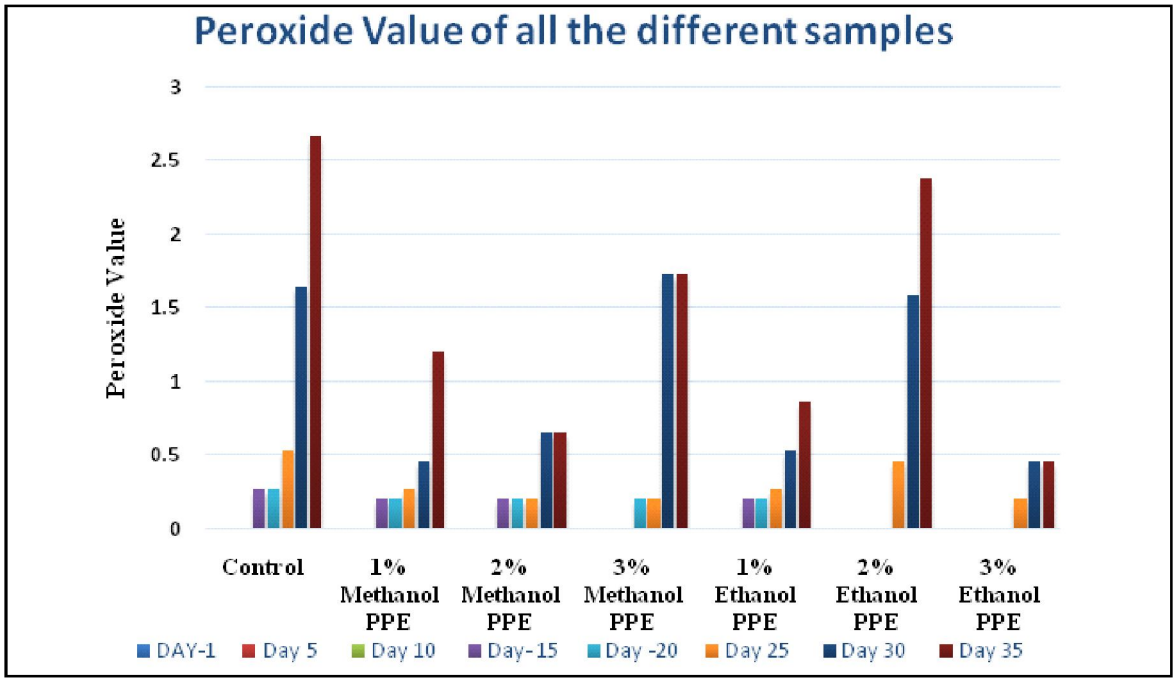

Figure 3: Effect of potato peel extract on nachos oxidation expressed as peroxide value formation.

3.4 Application of potato peel extracts in nachos

3.4.1 Sensory evaluation

Sensory evaluation was conducted in order to know the overall acceptability of the nachos. The scores for each sensory characteristic were taken into consideration for different formulation groups and the mean of the overall acceptability was calculated and is presented in Figure 2.

3.4.2 Peroxide value (PV)

The peroxide content of the different samples (nachos with different concentrations of potato peels) was determined using the volumetric estimation method. This was done for 35 days at regular interval of five days. For the first 10 days of storage, there was no significant increase in peroxide value. The increase in PV was observed after ten days of storage of nachos at room temperature as shown in Figure 3.

When compared to other formulation groups, nachos samples without antioxidants (control) exhibited the highest peroxide value 2.66 ± 0.115 meq/kg at the end of the storage period. The peroxide values of ethanol extracts of potato peel at 1%, 2%, and 3% were found to be 0.86 ± 0.115, 2.38 ± 0.0 and 0.46 ± 0.121 meq/kg, respectively and for 1%, 2%, 3% methanol extract of potato peel were 1.2 ± 0.0,0.66 ± 0.115, 1.73 ± 2.66 meq/kg, respectively after 35 days of storage of nachos.

3.4.3 Acid value

In the present study, another parameter that was used for determining the oxidation in nachos was the acid value test. The volumetric titration method was used to determine the acid value. The acidity of nachos was analyzed at regular intervals of 5 days for a total of 35 days. There was a gradual increase in acid value (Figure 4). Initially, FFA for control was found to be 1.726 ± 0.178 mg KOH/g on day 1 and after 35 days of storage of nachos, the FFA was found to be 6.10 ± 0.0 mg KOH/g. The increased FFA could be due to the breaking of unsaturated fatty acid double bonds in lipids when nachos are stored at room temperature, as previously described (Noor and Augustin, 1984). FFA for 1%, 2%, 3 % ethanol extract of potato peel was found to be 5.69 ± 0.352, 4.88 ± 0.0, 4.27 ± 0.0 mg KOH/g, respectively and for 1%, 2%, 3% methanol extract of potato peel was found to be 5.28 ± 0.704, 4.47 ± 0.352, 5.07 ± 0.35 mg KOH/g, respectively. Hence, it is evident that 3% ethanol extract of potato peel gave better antioxidants as compared to other formulation groups.

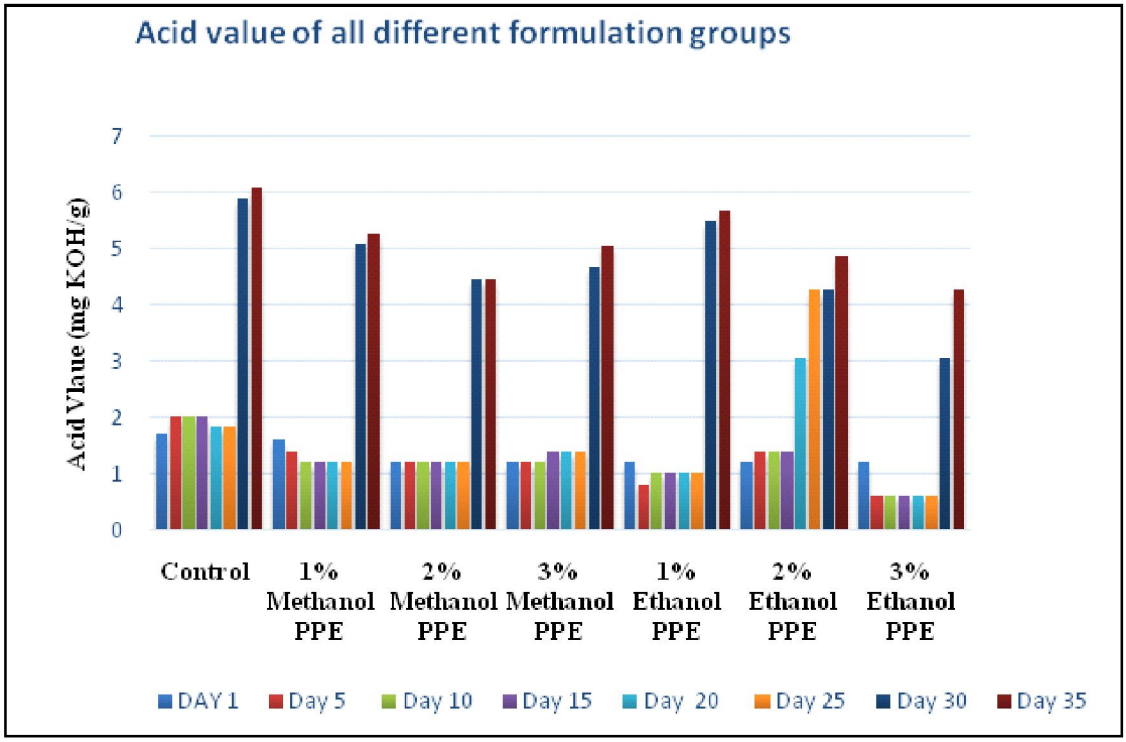

Figure 4: Acid value of oil extracted from nachos with different concentrations of potato peel extract.

4. Discussion

The composition of potato peels (Kufri Bahar) was determined. The composition, colour, breed of potatoes, and their peels vary according to the different geographical cultivation areas. Thus, it is important to estimate the composition of the variable being studied. Table 1 represents the chemical composition of potato peels (Kufri Bahar).

Carbohydrates and protein content were found to be consistent with the previous data reported (Javed *et al.*, 2019). Generally, potato peels contain 85% of moisture; however, in the present study, it was found to be low, *i.e.*, only 15.4%. The possible reason for deviation could be due to the determination of chemical composition in the different varieties of potato used for the study. Similarly, the % of fat in Kufri Bahar was found to be higher, *i.e.*, 1.65% as compared to other geographical areas (0.1-0.2) (Javed *et al.*, 2019).

In one of the studies, calcium content was reported to be 0.305 g/ 100 g of potato peels (Rowayshed *et al.*, 2015). However, the calcium content in the Kufri Bahar was found to be very low, *i.e.*, 0.15 mg/100 g of potato peels. Ramsay's method was used for the estimation of iron content. However, the results were inconclusive.

The total phenolic levels in potato peels were measured since phenolics are major groups that act as primary antioxidants. The

amount of phenolic compounds extracted depends upon the solvent used, its polarity, and the solubility of the phenolic compounds from the plant materials (peels) (Mohdaly *et al*., 2010). In the ethanolic extract of potato peels, the amount of phenolic compounds was found to be higher as compared to the methanolic extract of potato peel (Table 2). However, the deviation was observed from the data reported by (Rowayshed *et al*., 2015). The possible reason can be due to different varieties of potato used.

Free radical scavenging activity was estimated by using DPPH assay. The test is simple, quick, and widely used. The presence of high amounts of TPC and total flavonoid content in the potato peels may explain their increased DPPH radical scavenging abilities. It could be concluded that the scavenging effects of potato peels extracted on DPPH radicals were excellent, especially in the case of ethanol extract.

Sensory evaluation is a science that studies, analyses and interprets people's reactions to items as they are perceived *via* their senses. It is a way of figuring out whether product differences are noticed, what causes them, and whether one product is preferred over another. There was an effect on the taste and odour of nachos after the incorporation of potato peel extract. All the nachos with different concentrations were well accepted as control. It was seen that the majority of panelists preferred nachos with 3% ethanol potato peel extract (PPE) compared to other different formulations of nachos as shown in Figure2. Thus, the addition of various concentrations does not contribute to any change in the sensory properties of nachos.

The primary oxidation of lipids, fats, and oils is indicated by peroxide value. The primary oxidation products are hydroperoxides, peroxides, and then polymers of peroxides. It detects rancidity in unsaturated oils and fats (Dermiş *et al*., 2012). In this study, the antioxidants were extracted from the potato peels then it was incorporated into nachos. If, the antioxidant from the natural source is effective, then the PV should be lower than the control which has no natural antioxidant in it. PV for all the seven variants containing different concentrations of antioxidants was determined. The PV of all samples was found to be lower than the control. These findings suggest that the potato peel extract in nachos can prevent lipid oxidation. Overall, the antioxidant potential of the ethanol extract of potato peel was higher than the other formulation groups.

Antioxidants are mainly added in order to improve oxidative stability. As a result, the PV values clearly indicate lipid peroxidation. Other tests, such as FFA, TBARS, and others, can be conducted to validate these findings.The acid value is defined as a number of milligrams of KOH (in milligrams) required to neutralize free fatty acids present in 1.0 g of an oil sample. A low acid value indicates the resistance to rancidity (Belsare and Badne, 2017). Thus, as compared to other formulations, the nachos without antioxidants (control) should have a high acid value. It is clearly seen that the addition of the various concentrations of the potato peel extracts retarded the development of the rancidity of nachos as shown in Figure 4. In comparison to the control, the extract samples had lower FFA levels. FFA levels in all samples increased significantly as storage progressed. These results are similar to the data reported by (El-Bana, 2012), *i.e.*, in processed foods, lipid peroxides were significantly reduced.

5. Conclusion

In the present study, potato peels were utilized to extract natural antioxidants. Potato peels are generally regarded as "waste" that is produced by potato processing industries; however, it contains a high amount of natural antioxidants and can be used as a food additive, enhancing the nutritive value of the product.The presence of phenolic compounds is related to antioxidant activity in peels. Nachos were made by incorporating various concentrations of potato peel extracts into them. From the study, it is evident that potato peels are rich in nutrients and antioxidant activity. Hence, it can be used as a source of natural antioxidants over synthetic antioxidants in food products containing fats and oils in order to reduce lipid peroxidation. The present study reveals that ethanol was the better solvent for the extraction of antioxidants. Ethanol also showed a higher antioxidant activity as compared to methanol. This study found that adding potato peel extract to nachos retarded the lipid peroxidation when compared to a control group (nachos without the antioxidant). Results of sensory evaluation showed that nachos with 3% ethanol PPE gave better acceptability as compared to control. These extracts have no significant effect on the product's organoleptic properties. As a result, potato peel extract can be used to extend the shelf life of foods containing fats and oils. It can be used for solid waste management as well. Also, natural antioxidants are safe for consumption and impart health benefits.

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Conflict of interest

The authors declare no conflicts of interest relevant to this article.

References

Al-Weshahy, A. and Rao, V. A. (2012). Potato peel as a source of important phytochemical antioxidant nutraceuticals and their role in human health: A review. Phytochemicals as nutraceuticals-global approaches to their role in nutrition and health. Intech. Open, DOI:10.5772/30459.

Belsare, G. W. and Badne, S. G. (2017). Study on physicochemical characterization of edible oils from agencies of Buldhana district. Int. J. Res. Pharm. Chem., **7**(4):525-529.

Ben-Gera, I. and Kramer, A. (1969). The Utilization of food industries wastes. Adv. Food Nutr. Res., **17**:77-152.

Baskaran, N and Subash, A (2021). *In vitro* DPPH and AChE inhibitory activity of hydroethanolic extract from *Camellia sinensis*. Ann. Phytomed., **10**(2):208-212. DOI: http://dx.doi.org/10.21276/ap.2021.10.2.29

Dermiº, S.; Can, S. and Doðru, B.(2012). Determination of peroxide values of some fixed oils by using the mFOX method. Spectroscopy Letters, **45**(5):359-363. DOI: https://doi.org/10.1080/00387010.2012.666702.

Dubey, P.; Jayant, S.K. and Srivastava, N. (2020). Preliminary phytochemical screening, FTIR and GC-MS analyses of aqueous, ethanolic and

methanolic extracts of stem of *Tinospora cordifolia* (Guduchi) for search of antidiabetic compounds. Ann. Phytomed., **9**(2):183-197.

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

El-Bana, M. A. (2012). Evaluation of natural antioxidants extracted from rice milling by products. J. Food and Dairy Sci., **3**(5):325-341. DOI:10.21608/jfds.2012.75399.

Gahlot V. and Yadav, D. K. (2021). Anticonvulsant effects of *Argemone mexicana* L. against maximal electro shock and pentyl-enetetrazole induced seizure in rats. Ann. Phytomed., **10**(2):312-317. http://dx.doi.org/10.21276/ap.2021.10.2.42.

Gebrechristos, H.Y. and Chen, W. (2018). Utilization of Potato peels as eco-friendly products: A review. Food Sci Nutr., **6**(6):1352-1356. DOI: 10.1002/fsn3.691.

Javed, A.; Ahmad, A.; Tahir, A.; Shabbir, U.; Nouman, M. and Hameed, A. (2019). Potato peel waste-its nutraceutical, industrial and biotechnological applications. AIMS Agric. Food, **4**(3):807. DOI: 10.3934/agrfood.2019.3.807.

Kavalan, R.;Abdussalam, A. K. and Gothandam, K. M. (2020). Phytochemical evaluation of *Amorphophallus smithsonianus* Sivad: A rare endemic species from Western Ghats, Kerala, India. Ann. Phytomed., **9**(2):271-276. DOI: 10.21276/ap.2020.9.2.26.

Lalas, S. and Dourtoglou, V. (2003). Use of rosemary extract in preventing oxidation during deep-fat frying of potato chips. J. Am. Oil Chem. Soc., **80**(6):579-583.DOI: https://doi.org/10.1007/s11746-003-0741-x.

Mohdaly, A. A.; Sarhan, M. A.; Smetanska, I. and Mahmoud, A. (2010). Antioxidant properties of various solvent extracts of potato peel, sugar beet pulp and sesame cake. J. Sci. Food Agric., **90**(2):218-226. DOI: 10.1002/jsfa.3796.

Moisture Content (AOAC, 1999). Analytical Methods. Retrieved October 14,2019, from http://kb.psu.ac.th/psukb/bitstream/2553/1573/2/271250_app.pdf.

Neilsen, S. (2010). Food Analysis. Fat Analysis. 4th ed., New York, NY: Springer, pp:117-132.

Neilsen, S. (2010). Food Analysis. Protein Analysis. 4th ed., New York, NY: Springer, pp:133-146.

Noor, N. and Augustin, M. A. (1984). Effectiveness of antioxidants on the stability of banana chips.J. Sci. Food Agric., **35**(7):805-812. DOI: https://doi.org/10.1002/jsfa.2740350719.

Pap, N.; Pongrácz, E.; Myllykoski, L. and Keiski, R. (2004). Waste minimization and utilization in the food industry: Processing of arctic berries, and extraction of valuable compounds from juice-processing by-products. Proceedings of the Waste Minimization and Resources use Optimization Conference, **10**:159-168.

Pokorny J.; Yanishlieva N. and Gordon M.H. (2001). Inhibiting Oxidation. Antioxidants in Food: Practical Applications.New York, Washington, CRC Press, pp:22-24.

Pourreza, N. (2013). Phenolic compounds as potential antioxidant. Jundishapur J. Nat. Pharm., **8**(4):149.DOI: 10.17795/jjnpp-15380.

Raghuramulu, N.; Madhavan, N. K.; Kalyanasundaram, S.; Madhavan, K. M.; Kalyansundaram, S.; Nair, K. and Nair, K. M. (2003). A manual of laboratory techniques.

Rice-Evans, C.; Miller, N. and Paganga, G. (1997). Antioxidant properties of phenolic compounds. Trends in Plant Sci., **2**(4):152-159. DOI: https://doi.org/10.1016/S1360-1385(97)01018-2.

Rothwell, C. S. (1927). The determination of calcium in whole oxalated blood. J. Biol. Chem.,**74**(2):257-263.

Rowayshed, G; Sharaf, A. M.; El-Faham, S. Y.; Ashour, M. and Zaky, A. A. (2015). Utilization of potato peels extract as source of phytochemicals in biscuits. Int. J. Sci.: Basic Appl., **8**(3):190-201.

Russ, W. and Meyer-Pittroff, R. (2004). Utilizing waste products from the food production and processing industries. Crit. Rev. Food Sci. Nutr., **44**(1):57-62. DOI: 10.1080/10408690490263778

Samotyja, U. (2019). Potato peel as a sustainable resource of natural antioxidants for the food industry. Potato Res., **62**(4): 435-451. DOI: https://doi.org/10.1007/s11540-019-9419-2..

Varley (1976). Reagents for serum iron estimation by Ramsay's Dipyridyl method. https://shodhganga.inflibnet.ac.in/bitstream/10603/60048/20/20_appendix%206.pdf/ Accessed 1st October 2019.

Venkatachalam, T; Chitra, M; Kalaiselvi, P; Chitra, A; Sumathi, K; Suresh Babu, C. M.; Senthilkumar, N. and Sattanathan, K. (2021). Phytochemical screening and antidiabetic potentiality of *Pavetta indica* L. (Angiosperms: Rubiaceae) methanol extract on streptozotocin induced diabetic mice. Ann. Phytomed., **10**(2):292-297. DOI: http://dx.doi.org/10.21276/ap.2021.10.2.39.

Yuen, S. H. and Pollard, A. G. (1951). The Fiske Subbarow method for determining phosphate with special reference to soil extracts. J. Sci. Food Agric., **2**(1):36-42.

Zhang, H.; Fen, X.; Yu, W.; HU, H. H, and DAI, X. F. (2017). Progress of potato staple food research and industry development in China.J. Integr. Agric., **16**(12):2924-2932.DOI: https://doi.org/10.1016/S2095-3119(17)61736-2.

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