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Study on physico-chemical and antioxidant properties of pomegranate peel

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Abstract

The pomegranate and their derivative parts contain various phenolic activities. The pomegranate peel had the highest antioxidant activity as compared to other parts of pomegranate fruit. It contains bioactive compounds such as Flavonoids, Polyphenols, Ellagitannins compounds (Gallic acid, Ellagic acid, Punicalagin, Punicalin, luteolin, Quercetin, kaempferol, glycosides, Pedunculagin), minerals (calcium, phosphorus, nitrogen, potassium, magnesium, sodium), and polysaccharide composite. In this study, the influence of different drying methods on the properties of two varieties (Bhagwa and Ganesh) of pomegranate peels was investigated. The pomegranate peel of both varieties was dried in a different method such as Freeze drying (-45 °C for 94 hrs), Tray Oven drying (60 °C for 29 hrs) and Sun drying (72 hrs). In this experiment used five different solvents such as methanol, ethanol, water, acetone, and hexane. In this study observed the freeze-dried sample of Ganesh pomegranate peel showed highest phenolic activity in the water, Flavonoid activity in ethanol and FRAP activity in methanolic extraction. The primary antioxidant (DPPH) activity was highest observed in GSD-A followed by GSD-M and GSD-E. The Bhagwa variety of pomegranate peel extract showed the highest phenolic and FRAP activity in the Methanolic extraction of freeze-dried and tray dried peel sample. The ethanolic extraction of Bhagwa tray dried peel showed highest flavonoid and antioxidant (DPPH) activity.

Keywords: pomegranate peel, drying, solvent extraction, antioxidant properties

1. Introduction

India has the largest production of pomegranate (*Punica Granatum*) supervene by Iran and China (World Pomegranate Market, 2015) [33]. The native's countries of the pomegranate fruit are southern Caspian belt (Iran) and Northeast Turkey (Janick, 2007) [15]. The pomegranate fruit is cultivated in different various regions such as tropical, subtropical and semi-arid (Ercisli *et al.* 2007) [11]. It belongs to the Punicaceae family, also known as the 'Super Fruit' due to its excellent properties such as nutritional value, antioxidant capacity. Pomegranate food processed foods have higher consumer demand in the market. Pomegranate consumed as fresh fruit and functional foods such as juice, beverages, jams, jellies, and others. Pomegranate and their derivatives parts extracts used as botanical ingredients in herbal medicines and dietary supplements in food and pharma sector (Elfalleh *et al.* 2012; Sharma & Maity, 2010) [10, 28]. Pomegranate peel is the nutritive by-product of pomegranate after juice extraction. It showed excellent properties such as antibacterial, anti-oxidants, anti-cancer activity, anti-atherosclerotic and wound healing properties (Navarro *et al.* 1996; Chidambara *et al.* 2004; Adhami *et al.* 2006; S. Rajan *et al.* 2011) [22, 8, 1, 5]. Pomegranate peel contains bioactive compounds such as flavonoids, polyphenols, ellagitannins compounds (Gallic acid, Ellagic acid, Punicalagin, Punicalin, luteolin, Quercetin, Kaempferol, Glycosides, Pedunculagin), minerals (calcium, phosphorus, nitrogen, potassium, magnesium, sodium), and polysaccharide composite (Jahfar *et al.* 2003; Van Elswijk *et al.* 2004; Amakura *et al.* 2000; Seeram *et al.* 2005; Li *et al.* 2006; Mirdehghan & Rahemi, 2007) [14, 32, 3, 26, 27, 18, 20]. It has delineated the pomegranate peel have the highest antioxidant activity as compared to other parts (Kulkarni *et al.* 2007; Zahin *et al.* 2010) [17, 34].

2. Objective of the Study

1. To study the determination and investigation the best varieties of pomegranate peel powder to extract phenolic, flavonoids contents and antioxidant activity.
2. To optimize the best drying techniques and solvents for extraction phenolic and antioxidant activity.

3. Material and Method

3.1 Experimental design for drying fresh Pomegranate Peel

Fresh pomegranate (*Punica Granatum* L) fruits of Bhagwa

and Ganesh variety fruit peel were subjected to drying. The peel sample was drying in a freeze dryer (94 hours at-45 °C) Tray drying (60 °C for 29 hours) and sun drying (72 hours).

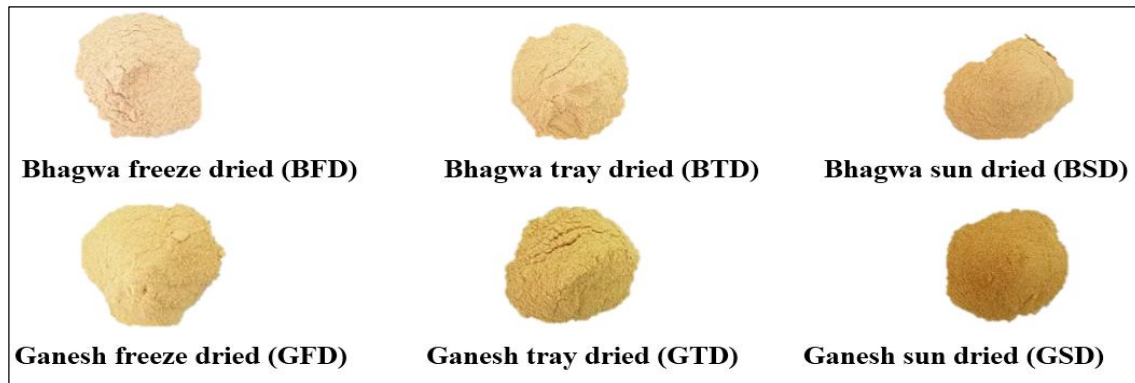


Plate 1: Pomegranate Peel powder subject to different drying methods

3.2 Extraction

The dried powder sample of pomegranate peel respected varieties was used to obtain the clear extract for further analysis. The extract was prepared using different solvents (Methanol, Ethanol, Water, Acetone, and Hexane). The extraction procedure was used as per the method is given by (Al-Zoreky, 2009; Shibani *et al.* 2012; Dahham *et al.* 2010) [2, 29, 9]. The obtained extract using different solvents was used for Physico-chemical analysis (ash, fat, moisture, protein, total phenolic contents and total flavonoids contents) using standard methods.

The antioxidant property was assessed through (AOAC 2011.011) DPPH and FRAP assay method as prepared by (Brand-Williams, *et al.* 1995; Benzie, I. & Strain, J. 1996) [7, 6].

3.3 Statical analysis

The ANOVA and Duncan triplicates range test $P < 0.05$ level significance were appointed to data for analysis using SPSS statistical software version (IBM SPSS 20.0). The results were expressed as mean \pm SD.

4. Results and Discussion proximate and chemical composition

4.1 A considerable variation was observed in some of the Physico-chemical, total phenolic, Flavonoids, FRAP and antioxidant properties of the peel sample extracted in different solvents. Some of the physical characteristics of both the varieties of pomegranate fruit peels are presented in Table 1. The a, b, c, d... represent significant differences between dried pomegranate peel powder samples of both varieties.

Table 1

| S. No. | Sample | Moisture (%) | Protein (%) | Ash (%) | Fat (%) |
|--------|--------|-------------------------------|------------------------------|-------------------------------|------------------------------|
| 1 | BFD | 9.65 \pm 0.11 ^a | 1.33 \pm 0.04 ^a | 3.75 \pm 0.06 ^a | 0.46 \pm 0.01 ^a |
| 2 | BTD | 7.68 \pm 0.48 ^{bc} | 1.34 \pm 0.02 ^a | 2.34 \pm 0.11 ^d | 0.39 \pm 0.01 ^b |
| 3 | BSD | 8.15 \pm 0.19 ^b | 1.26 \pm 0.03 ^b | 2.68 \pm 0.11 ^b | 0.35 \pm 0.02 ^c |
| 4 | GFD | 7.73 \pm 0.10 ^{bc} | 0.96 \pm 0.03 ^d | 2.54 \pm 0.12 ^{bc} | 0.39 \pm 0.00 ^b |
| 5 | GTD | 7.38 \pm 0.28 ^c | 1.12 \pm 0.02 ^c | 2.37 \pm 0.07 ^{cd} | 0.39 \pm 0.01 ^b |
| 6 | GSD | 7.53 \pm 0.19 ^c | 0.93 \pm 0.02 ^d | 2.40 \pm 0.07 ^{cd} | 0.34 \pm 0.01 ^c |

The ash (%), fat (%), moisture content (%) and protein (%) contents of dried pomegranate peels powder are presented in Table 1. The high moisture content (9.65 \pm 0.11) was observed in BFD (Bhagwa freeze dried) pomegranate peel. Ganesh tray

dried (GTD) and sun-dried (GSD) pomegranate peel powder showed similar and lowest range of moisture content 7.38 \pm 0.28 and 7.53 \pm 0.19 respectively. Ash content of the pomegranate peels varied from 2.34 to 3.75%. Bhagwa freeze dried (BFD) pomegranate peel exhibit more ash content (3.75 \pm 0.06) as compared to other dried powder samples. Tray dried sample of the Bhagwa variety (BTD) showed lowest ash content (2.34 \pm 0.11). The fat content of pomegranate peels varied from 0.34 \pm 0.01 to 0.46 \pm 0.01. The maximum fat content was observed in Bhagwa freeze dried (BFD) powder of PGP. Minimum fat content (0.34 \pm 0.01) was recorded for (GSD) Sun-dried PGP of Ganesh variety. In this study investigated the (BFD) freeze-dried and (BTD) tray dried pomegranate peel sample of Bhagwa variety showed highest proteins content 1.33 \pm 0.04 and 1.34 \pm 0.02 respectively, as compared to other dried peel powder. The low protein content was observed in GFD and GSD (Ganesh freeze and sun-dried) 0.96 \pm 0.03 and 0.93 \pm 0.02 respectively.

4.2 Color

The pomegranate dried peel colors were measured using a colorimeter and the "L*," "a*," "b*," and "C" chroma values were recorded in Table no 2. The highest value of the peel lightness (L value) was observed in GTD (72.99 \pm 0.19), GFD (70.75 \pm 0.59) and GSD (70.21 \pm 0.83). A* (redness) value was the highest in BSD (9.56 \pm 0.10) followed by BFD (9.14 \pm 0.27). The Bhagwa sun-dried (BSD) peel powder was darker than all other dried powder of pomegranate peel. B* values highest found in Ganesh freeze dried (GFD-35.28 \pm 0.39) followed by GTD and GSD 34.22 \pm 0.15 and 33.71 \pm 0.19 respectively. The lowest L*, a*, and b* value were recorded in GSD (61.65 \pm 0.20), GTD (4.57 \pm 0.37) and BSD (19.56 \pm 1.04) respectively. The color (C*) intensity was highest observed in GSD (36.61 \pm 0.02) followed by GFD (36.11 \pm 0.01) and lowest observed in BSD (21.76 \pm 0.21). The, b, c, d... represent a significant difference between dried pomegranate peel powder color values of samples.

Table 2

| S. No. | Sample | L* | a* | b* | Color intensity (C*) |
|--------|--------|-------------------------------|------------------------------|-------------------------------|-------------------------------|
| 1 | BFD | 70.75 \pm 0.59 ^b | 9.14 \pm 0.27 ^a | 20.18 \pm 0.25 ^c | 22.15 \pm 0.02 ^c |
| 2 | BTD | 63.97 \pm 0.47 ^c | 8.51 \pm 0.47 ^b | 20.64 \pm 0.75 ^c | 22.32 \pm 0.03 ^c |
| 3 | BSD | 52.96 \pm 2.18 ^c | 9.56 \pm 0.10 ^a | 19.56 \pm 1.04 ^d | 21.76 \pm 0.21 ^d |
| 4 | GFD | 70.21 \pm 0.83 ^b | 7.73 \pm 0.44 ^c | 35.28 \pm 0.39 ^a | 36.11 \pm 0.01 ^a |
| 5 | GTD | 72.99 \pm 0.19 ^a | 4.57 \pm 0.37 ^d | 34.22 \pm 0.15 ^b | 34.52 \pm 0.02 ^b |
| 6 | GSD | 61.65 \pm 0.20 ^d | 7.85 \pm 0.11 ^c | 33.71 \pm 0.19 ^b | 36.61 \pm 0.02 ^a |

4.3 Total phenolic content (TPC)

The phenolic contents act as antioxidants due to their redox properties. The free radical scavenging of phenolic contents has the ability to facilitate by their hydroxyl groups. The concentration of phenolic compounds could use as a rapid screening of anti-oxidative properties (M.A. Soobrattee *et al.* 2005) [19]. The total phenolic contents (TPC) of both Ganesh and Bhagwa varieties of pomegranate peel extract were investigated with 5 types of different solvents. In this study, it was observed the (BFD-M) freeze dried peel power of Bhagwa variety showed highest phenolic content (485.036±0.31 mg/g) in Methanolic extraction. Ethanolic extraction of Bhagwa Tray dried (BTD-E) powder was showed total phenolic content 465.157±2.00 mg/g. The lowest phenolic activity of Bhagwa pomegranate peel was observed in BFD-H, BTD-H and BSD-H, 20.854±0.79, 20.854±0.36 and 32.612±0.37 respectively. Total phenolic contents of the different dried pomegranate peel powder of Ganesh variety varied from 13.278±0.85 to 453.703±0.45 mg/g. The highest phenolic content (453.703±0.45 mg/g) activity was observed in GFD-W (aqueous extract of the Ganesh freeze dried

powder) and 427.399±0.27 mg/g in GFD-E (ethanolic extraction of the Ganesh freeze dried powder). Similarly, as Bhagwa peel powder, it was also showed the lower activity of the total phenolic content in hexane. The GFD-H, GTD-H, and GSD-H (Ganesh freeze dried, Tray dried and Sun-dried pomegranate peel extract) were showed 19.339±0.20, 13.278±0.85 and 16.430±0.27 respectively. The results of this study revealed the freeze-drying method and methanol solvents are most effective for extraction phenolic content activity in Bhagwa pomegranate peel extracts. The freeze drying method and aqueous extraction of Ganesh pomegranate peel powder are the best for extracting phenolic content as compare to other drying method and solvent. The phenolic extraction of both varieties (Bhagwa & Ganesh) pomegranate peel powder extract was showed lowest in hexane. So it was observed, the hexane is not a good solvent for phenolic content extraction of pomegranate peel powder. The total phenolic content activity of both varieties pomegranate peel powder extract showed in Table 3 & 4. The comparison of the total phenolic content of both varieties is expressed in Figure 1.

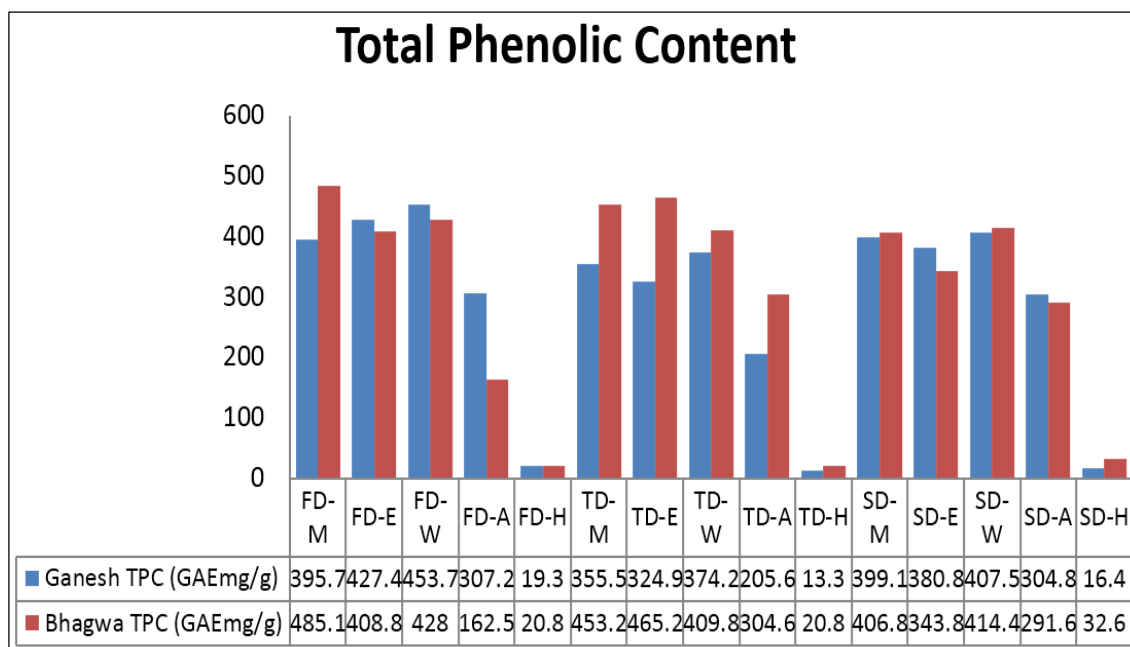


Fig 1: Comparison between Bhagwa and Ganesh pomegranate varieties peel extract Total phenolic content

4.4 Total Flavonoids content (TFC)

The total Flavonoid content activity of both varieties of pomegranate peel powder extracts was expressed in Table 3 & 4. The total flavonoids contents were highest observed in Ganesh freeze dried (GFD) powder peel in ethanolic (1470.234±1.56) and acetone 1468.672±0.78 extraction. In the Ganesh varieties of pomegranate peel, methanolic extraction of both varieties (GFD-M and GTD-M) showed similar flavonoid content activity 1444.453±1.56 and 1444.974±0.90 respectively. The lowest flavonoids content was observed in GFD-H (439.765±0.78) and GTD-H (360.598±0.45). The hexane solvent showed flavonoids content in Ganesh sun-dried (GSD-H) peel powder extract is 1060.338±0.45, which is a high quantity as compared to other dried peel extraction of solvents. The aqueous extraction of Ganesh pomegranate peel was 1403.307±0.90, 1438.463±0.90 and 1305.651±1.19 in freeze-dried, tray dried and a sun-dried

sample of Ganesh variety. Overall in Ganesh varieties, the hexane solvents extraction showed lowest flavonoids contents in peel extract. The ethanolic extraction of a Tray dried sample of Bhagwa variety pomegranate peel showed highest flavonoids contents 1446.797±0.00 followed by BFD (1443.672±0.00) in the Methanolic extract. The lowest value of flavonoids contents is observed in hexane solvents (BFD, BTD & BSD) extraction. The Bhagwa tray dried (BTD-H) peel sample showed lowest flavonoids contents as compared to other dried sample and solvents. This study results revealed the ethanol solvents are more effective as compared to other solvents for extraction flavonoids contents. Both varieties of pomegranate peel powder extract showed highest flavonoid activity in ethanol in two different dried peels (Freeze and Tray dried). The comparison of the total flavonoids content of both varieties is expressed in Figure 2.

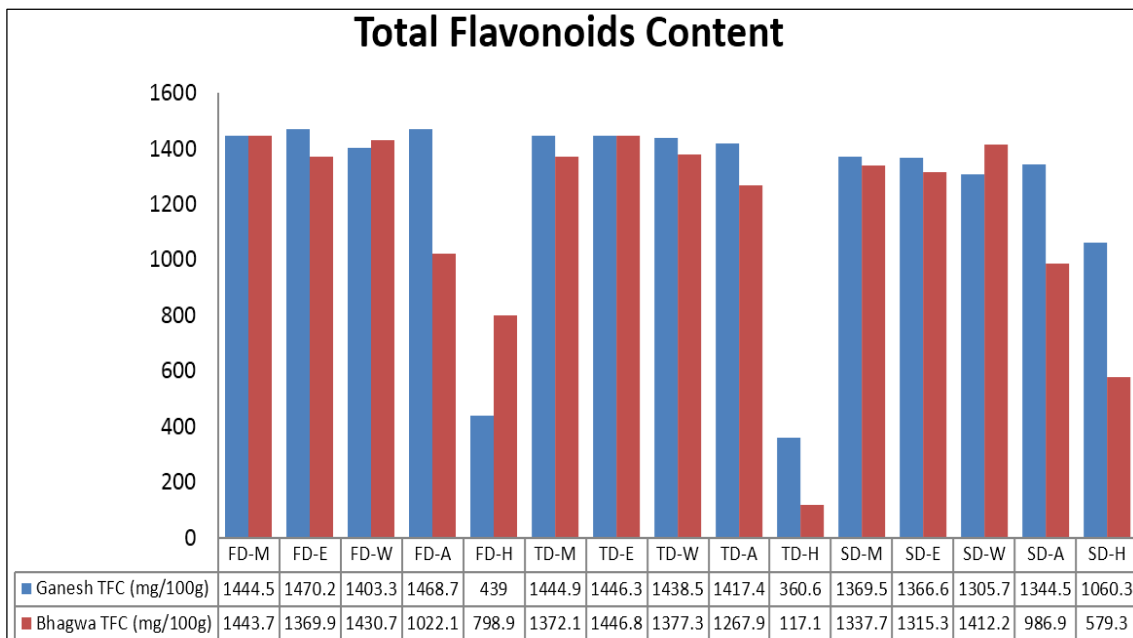


Fig 2: Comparison between bhagwa and ganesh pomegranate varieties peel extract total flavonoid content activity

4.5 Antioxidant activity (DPPH assay)

The Free radicals are involved in many types of disorders and disease such as cancer and AIDS, etc. Antioxidants help to reduce the risk of disease and their management through scavenging power (Koleva *et al.* 2002; Pourmorad F. *et al.* 2006) [16, 24]. The antioxidant capacity of the both Bhagwa and Ganesh varieties of pomegranate peel is expressed in Table 3 & 4. The highest radical scavenging activity (98.125±0.00%) was recorded in (GSD-A) Ganesh variety of sun-dried pomegranate peel extraction in acetone. The freeze-dried sample in methanol, ethanol extract showed radical scavenging activity 96.220±0.06% and 96.470±0.00%. It was observed in this study, the tray dried (GTD-H) and freeze dried (GFD-H) pomegranate peel extract in hexane showed lowest (4.636±0.22% and 6.564±0.57%) radical scavenging activity as compared to another extract. Acetone solvent

extract of freeze-dried (GFD-A) and Tray dried (GTD-A) PGP extract showed 94.866±0.00 and 94.866±0.0 respectively. The Bhagwa variety of pomegranate peel extract showed the highest antioxidant activity (BTD-E) 98.694±0.23% and (BSD-M) 98.578±0.05%. The Methanolic extract in Bhagwa freeze, tray, and sun-dried pomegranate peel showed 96.750±0.13%, 98.230±0.05%, and 98.230±0.05%. The lowest (27.676±0.15%) radical scavenging activity was observed in BFD-H. Finally, it was concluded the acetone solvent is more effective for radical scavenging activity in a Ganesh variety of PGP followed by Methanolic and ethanolic extract. The ethanol solvent is more effective as compared to other solvents and the hexane solvent showed lowest anti-radical scavenging activity in both varieties. The DPPH comparative data of PGP are expressed in Fig no. 3.

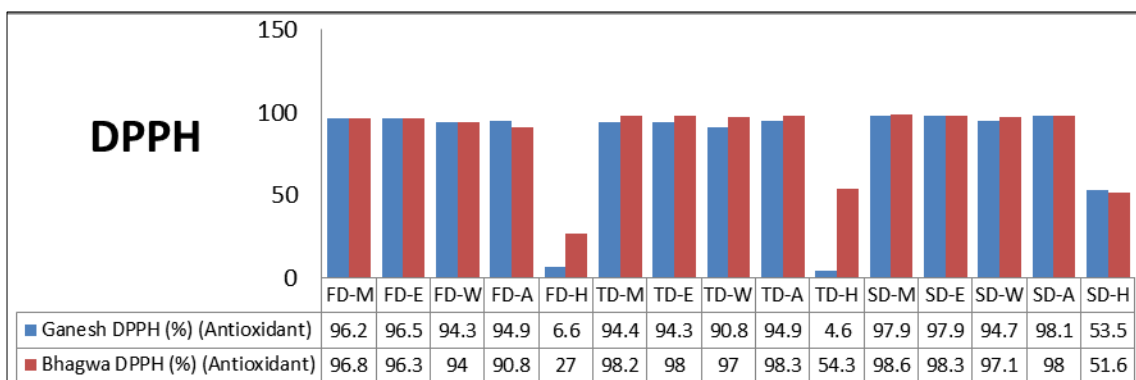


Fig 3: Comparison between Bhagwa and Ganesh pomegranate varieties peel extract radical scavenging activity

4.6 Ferric reducing antioxidant power (FRAP)

The free radical antioxidant activity of both dried varieties of pomegranate peel extract in a different solvent is determined by using the FRAP assay method. It is shown in Table 3 & 4. The pomegranate fruits and their parts antioxidant activity have been investigated in the many studies (Mousavinejad G. *et al.* 2009; Naveena BM. *et al.* 2008; Tezcan F. *et al.* 2009) [21, 23, 31]. The maximum antioxidant activity of 1.977±0.01 (mM AAE/L) was found in Ganesh freeze-dried (GFD-M) peel in the methanol extract followed by GSD-M and GTD-

M. The Methanolic extract of the Ganesh pomegranate peel powder showed highest antioxidant activity in all dried samples. The lowest FRAP activity was observed in hexane solvents. The hexane solvent showed in GFD-H is (0.041±0.00), GTD-H (0.003±0.00), and GSD-H (0.003±0.00) showed lowest FRAP activity as compared to other solvent extraction. Ethanolic and aqueous extraction showed similar Frap activity in all dried samples of ganesh varieties. GFD-E and GFD-W showed 0.973±0.00 and 0.992±0.04, GTD-E and GTD-W were showed 0.965±0.00

and 0.908 ± 0.01 , GSD-E and GSD-W were showed 0.948 ± 0.00 and 0.838 ± 0.01 (mM AAE/L) respectively. The Bhagwa varieties of pomegranate peel powder extract were showed highest 1.541 ± 0.05 , FRAP activity in sun-dried (Methanolic extract) pomegranate peel followed by freeze-dried in methanol (1.311 ± 0.00). The ethanolic extraction in all three dried samples showed similar activity, it was observed in BFD-E (0.979 ± 0.00), BTD-E (0.979 ± 0.00), and BSD-E (0.958 ± 0.00) respectively. The hexane solvent was

showed lowest FRAP activity in Bhagwa freeze dried, tray dried and sun-dried peel powder extract 0.313 ± 0.00 , 0.073 ± 0.00 and 0.086 ± 0.00 respectively. Overall, it was concluded the Methanolic extraction is more effective as compared to other solvents and Hexane solvents were showed lowest FRAP activity in both varieties of PGP extract. Comparison between both variety peel powder FRAP value is in different solvents are expressed in Figure 4.

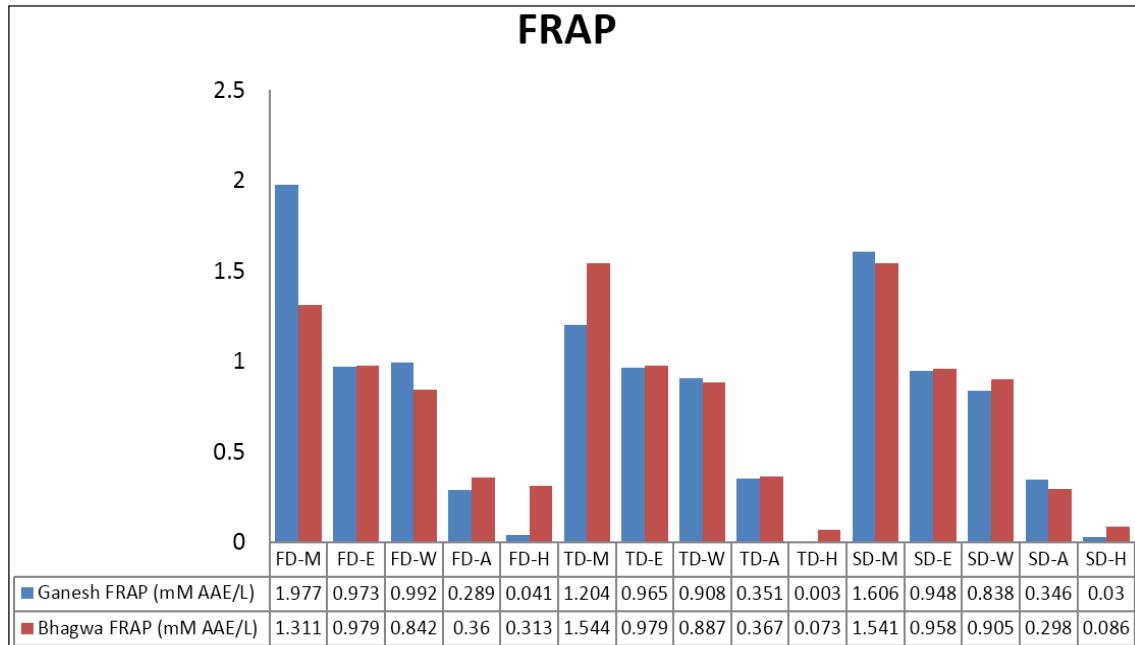


Fig 4: Comparison between bhagwa and ganesh pomegranate varieties peel extract FRAP activity

Table 3. TPC, TFC, DPPH, and FRAP value of Ganesh Pomegranate Peel extract in different solvents. The a, b, c,

d...n represent significance difference between both varieties of pomegranate peel extract.

Table 3

| S. No. | Sample | TPC (GAE mg/g) | TFC (mg/100g) | FRAP (mM AAE/L) | DPPH (%) (Antioxidant) |
|--------|--------|----------------------|-----------------------|--------------------|------------------------|
| 1 | GFD-M | 395.703 ± 1.36^c | 1444.453 ± 1.56^b | 1.977 ± 0.01^a | 96.220 ± 0.06^b |
| 2 | GFD-E | 427.399 ± 0.27^b | 1470.234 ± 1.56^a | 0.973 ± 0.00^d | 96.470 ± 0.00^b |
| 3 | GFD-W | 453.703 ± 0.45^a | 1403.307 ± 0.90^c | 0.992 ± 0.04^d | 94.259 ± 0.61^e |
| 4 | GFD-A | 307.218 ± 0.48^j | 1468.672 ± 0.78^a | 0.289 ± 0.00^e | 94.866 ± 0.00^c |
| 5 | GFD-H | 19.339 ± 0.20^m | 439.765 ± 0.78^k | 0.041 ± 0.00^f | 6.564 ± 0.57^h |
| 6 | GTD-M | 355.521 ± 0.37^h | 1444.974 ± 0.90^b | 1.204 ± 0.02^c | 94.438 ± 0.00^{de} |
| 7 | GTD-E | 324.975 ± 1.51^i | 1446.276 ± 1.19^b | 0.965 ± 0.00^d | 94.331 ± 0.00^e |
| 8 | GTD-W | 374.248 ± 1.99^g | 1438.463 ± 0.90^c | 0.908 ± 0.01^d | 90.766 ± 0.06^f |
| 9 | GTD-A | 205.642 ± 0.41^l | 1417.370 ± 0.90^d | 0.351 ± 0.00^e | 94.866 ± 0.00^c |
| 10 | GTD-H | 13.278 ± 0.85^o | 360.598 ± 0.45^j | 0.003 ± 0.00^f | 4.636 ± 0.22^i |
| 11 | GSD-M | 399.097 ± 0.10^d | 1369.453 ± 1.35^f | 1.606 ± 0.33^b | 97.960 ± 0.00^a |
| 12 | GSD-E | 380.793 ± 0.10^f | 1366.588 ± 0.90^g | 0.948 ± 0.00^d | 97.905 ± 0.00^a |
| 13 | GSD-W | 407.460 ± 0.37^c | 1305.651 ± 1.19^i | 0.838 ± 0.01^d | 94.707 ± 0.05^{cd} |
| 14 | GSD-A | 304.854 ± 0.96^k | 1344.453 ± 1.35^h | 0.346 ± 0.02^e | 98.125 ± 0.00^a |
| 15 | GSD-H | 16.430 ± 0.27^n | 1060.338 ± 0.45^j | 0.030 ± 0.00^f | 53.527 ± 0.05^g |

Table 4. TPC, TFC, DPPH, and FRAP value of Bhagwa Pomegranate peel extract in different solvents. The a, b, c,

d...n represent a significance difference between both varieties of pomegranate peel extract.

Table 4

| S. No. | Sample | TPC (GAE mg/g) | TFC (mg/100g) | FRAP (mM AAE/L) | DPPH (%) (Antioxidant) |
|--------|--------|----------------------|-----------------------|--------------------|------------------------|
| 1 | BFD-M | 485.036 ± 0.31^a | 1443.672 ± 0.00^b | 1.311 ± 0.00^b | 96.750 ± 0.13^f |
| 2 | BFD-E | 408.854 ± 0.48^f | 1369.973 ± 2.74^f | 0.979 ± 0.00^c | 96.286 ± 0.20^g |
| 3 | BFD-W | 428.006 ± 0.55^d | 1430.651 ± 1.96^c | 0.842 ± 0.00^e | 94.894 ± 0.25^h |
| 4 | BFD-A | 162.490 ± 0.18^k | 1022.057 ± 0.90^j | 0.360 ± 0.01^f | 90.832 ± 0.13^i |
| 5 | BFD-H | 20.854 ± 0.79^m | 798.880 ± 0.45^l | 0.313 ± 0.00^i | 27.676 ± 0.15^j |
| 6 | BTD-M | 453.157 ± 1.38^c | 1372.057 ± 1.79^f | 1.544 ± 0.02^a | 98.230 ± 0.05^{bc} |
| 7 | BTD-E | 465.157 ± 2.00^b | 1446.797 ± 0.00^a | 0.979 ± 0.00^c | 98.694 ± 0.23^a |

| | | | | | |
|----|-------|---------------------------|----------------------------|-------------------------|---------------------------|
| 8 | BTD-W | 409.763±1.61 ^f | 1377.265±2.34 ^e | 0.887±0.00 ^d | 97.476±0.08 ^d |
| 9 | BTD-A | 304.551±0.20 ⁱ | 1267.890±0.78 ⁱ | 0.367±0.00 ^f | 98.346±0.00 ^b |
| 10 | BTD-H | 20.854±0.36 ^m | 117.109±1.56 ⁿ | 0.073±0.00 ^h | 54.279±0.05 ^j |
| 11 | BSD-M | 406.854±1.58 ^g | 1337.682±1.19 ^g | 1.541±0.05 ^a | 98.578±0.05 ^a |
| 12 | BSD-E | 343.763±1.66 ^h | 1315.286±1.62 ^h | 0.958±0.00 ^c | 98.259±0.00 ^{bc} |
| 13 | BSD-W | 414.369±0.10 ^e | 1412.161±1.19 ^d | 0.905±0.00 ^d | 97.069±0.05 ^e |
| 14 | BSD-A | 291.642±0.75 ^j | 986.901±0.45 ^k | 0.298±0.00 ^g | 98.085±0.00 ^c |
| 15 | BSD-H | 32.612±0.37 ^l | 579.348±1.19 ^m | 0.086±0.00 ^h | 51.639±0.10 ^k |

BFD= Bhagwa freeze dried, BTD= Bhagwa tray dried, BSD= Bhagwa sun-dried, GFD=Ganesh freeze dried, GTD=Ganesh tray dried, GSD= Ganesh sun-dried (M= methanol, E= ethanol, W= water, A= acetone, H= hexane)

5. Conclusions

As a continuation of our study of Physicochemical and antioxidant properties of different dried pomegranate peel powder extract using different organic solvents, and investigated Physiochemical and *in vitro* antioxidant activity, phenolic and Flavonoids activity. The various extracts showed varying significant Physiochemical properties of pomegranate peel extract. The freeze drying method had higher total phenolic, flavonoid and antioxidant (FRAP) activity in Ganesh varieties of pomegranate peel powder extraction in aqueous, ethanol and methanol respectively. The highest radical scavenging (DPPH) was observed in sun-dried peel powder (Ganesh) extract in acetone followed by ethanol and methanol solvent. The PGP of Bhagwa variety in Methanolic extraction showed the highest antioxidant (FRAP) activity and total phenolic. The tray dried powder of Bhagwa pomegranate peel showed highest radical scavenging (DPPH) and total flavonoid in ethanolic extraction. For large scale operation, the freeze-drying method and extraction solvents (ethanol and Methanol) would be a better choice for extraction phenolic and flavonoid content for pharmaceutical use. The next stage after the extraction of phenolic bio-active compounds from pomegranate powder peel extract with suitable methods and other solvents for extract high phenolic, flavonoids, and antioxidant content. Further *In vivo* and *in vitro* studies are necessary to determine the application of pomegranate peel powder in new product development, food fortification, microencapsulation, medical and food packaging sector.

6. References

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