

Original Research Article

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Anti-cancer and Anti-microbial Potential of Nutraceutical Rich Under utilized Herb *Portulaca Oleracea* from Kashmir Region

Imtiyaz Murtaza^{1*}, Navreen Rashid¹, Omi Laila¹, Nisar Ahmad Ganie²
and M. Younus Wani²

¹Biochemistry and Molecular Biotechnology Laboratory,
Division of Basic Sciences and Humanities, SKUAST-K, J&K, India
²CoTS, Mirgund, SKUAST-K, J&K, India

*Corresponding author

ABSTRACT

Portulaca oleracea (commonly known as Nunner in Kashmir) is an underutilized wild vegetable in the Kashmir region. This vegetable is believed to be highly nutritional and quite health beneficial, however, has remained highly unexplored. Therefore, in the current study, the nutraceutical composition as well as antimicrobial and anticancerous potential of wild edible herb *Portulaca oleracea* (common purslane) was determined in its fresh as well as dried form. The results revealed that dried form comparatively contains higher carbohydrates (25.1±0.173%), crude protein (19.83±0.145%), crude fat (4.02±0.011%), crude fiber (7.19±0.017%), total soluble sugars (3.56±0.012%), reducing sugars (3.16±0.012%) and non-reducing sugars (0.40±0.023%). In addition, *Portulaca oleracea* proved to be a rich source of calcium (1366.66±0.120mg/100g), magnesium (943.93±0.713mg/100g), sodium (153.63±0.145mg /100g) and iron (47.66±0.088mg/100g) content. The nutraceuticals were also found to be present in appreciable amounts including total phenols 385.96±0.744mg/100g, total flavonoids 98.66±0.120mg/100g and total anthocyanins 881.76±0.088mg/100g, respectively. The antimicrobial assay demonstrated that *P. oleracea* has great potential to be used as an antimicrobial agent against *Staphylococcus aureus* and *E. coli* (EPEC) pathogens. Interestingly, the aqueous extracts of dried *P. oleracea* exhibited potent dose and time dependent cytotoxic effects against HL-60, MOLT-4 and T47-d cancer cell lines under *in vitro* conditions. Thus, through this study, we provide a scientific basis for nutraceutical rich *Portulaca oleracea* from Kashmir valley for its folklore or ethno-medicinal uses, and for its further exploitation as a highly useful alternative strategy for antimicrobial and anti-cancer drug development or as an adjuvant to existing therapies.

Keywords

Portulaca oleracea,
Nutraceuticals,
Antimicrobial,
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Introduction

In the present era, cancer remains a major global health concern, being one of the world's most deadly diseases. Despite significant breakthroughs in the understanding, prevention, and treatment of

this disorder, cancer is still the point of concern for the whole world. In 2018 nearly 18.1 million people around the world had cancer and 9.6 million died from the disease. This number will nearly double by 2040, with almost two thirds increase to occur in low and middle income countries (WHO, 2020).

This alarmingly high rate of mortality among cancer patients is a clear indication of insufficient efficiency of the current available medications and therapies including radiation, chemotherapy and surgery. Now-a-days, in addition to cancer burden, antibiotic resistance has also become a global issue and is recognized by the World Health Organization (WHO) as the greatest threat in the treatment of infectious diseases (WHO, 2020).

Three such infectious diseases have been ranked in top ten causes of death globally, including lower respiratory infections (3.1 million deaths), HIV/AIDS (1.5 million deaths) and tuberculosis (1.3 million deaths) excluding deaths due to recent COVID19 Pandemic. Although, some people are at greater risk than others but no one can completely avoid the risk of such infections especially with antibiotic resistant organisms that are difficult to treat, require costly and sometimes toxic alternatives. Therefore, the need of hour is to continue the search for much safer and more effective chemo-preventive anticancerous and antimicrobial agents to combat against such diseases.

Among the different regimes, since the immortal time natural plants or herbs have a long history of curbing oxidative stress related disorders and microbial diseases (Durgawale *et al.*, 2019). Recent, scientific data clearly indicates that the wild plants or herbs in addition to being a rich source of nutrients represent a potent resource of numerous bioactive nutraceuticals for the development of new antibiotics or anti-cancerous prototypes.

Therefore, the current trend across the globe is shifting towards the use of natural plant products (such as crude plant extracts) or a combination of nutraceuticals as a new source of potent and novel drugs with minimal side

effects (Khameneh *et al.*, 2019; Amaral *et al.*, 2019). Various edible wild plants apart from being rich source of nutrients have been reported to possess enormous medicinal potential due to the presence of such bioactive secondary metabolites (Kour *et al.*, 2018). As far as Jammu and Kashmir is concerned, the UT is bestowed with a huge variety of wild edible herbs having immense health promoting potential (Nabi *et al.*, 2017).

One such wild edible vegetable, *Portulaca oleracea* commonly called as “Nunner” in Kashmiri has recently gained a great deal of attention from nutritionalists worldwide due to its rich nutritional profile and biochemical composition. The dried aerial parts of this plant have been used for the treatment of fever, dysentery, diarrhea, carbuncle, eczema and hematochezia, with a recommended dose of 9-15µg in traditional system of medicines (Chugh *et al.*, 2019).

Though, the plant has been reported to possess several biological activities such as anticancer, antioxidant, anti-inflammatory and immunity enhancing properties, but it is highly unexplored in the UT of J&K (Tan *et al.*, 2013). Therefore, in the current study the nutraceutical, antimicrobial and anticancerous potential of wild *P. oleracea* from Kashmir region is reported.

Materials and Methods

Collection of plant sample

The current investigation was carried out in the Biochemistry and Molecular Biotechnology Laboratory, Division of Basic Sciences and Humanities, SKUAST-K, Shalimar, Kashmir J&K during the year 2016-17. The whole plant samples of *Portulaca oleracea* at their edible growth stage were collected from the open fields of Shalimar campus, SKUAST-K during the month of

July-August. The collected samples were rinsed thoroughly with distilled water and after draining water either used as such or shade dried, pulverized, and stored in an airtight container. The fresh as well as dried samples were then subjected to further investigations.

Nutritional analysis

The moisture, ash, crude fat and crude fiber content of *Portulaca oleracea* samples (dried as well as fresh) were determined by standard sustenance investigation techniques portrayed in the Association of Official Analytical Chemists (AOAC, 2000). The total carbohydrate, total soluble sugars, reducing sugars as well as non-reducing sugars and crude protein were assessed by methods reported in Thimmaiah (1999). For mineral estimation, *P. oleracea* samples (1gm) were taken in flasks, and 20 ml of di-acid (mixture of nitric acid and per chloric acid, in the ratio of 9:4) added to each flask.

The flasks were kept undisturbed overnight and next day placed on a hot plate (115-118 °C) for digestion till a watery transparent aliquot was obtained. The digested samples were filtered and diluted with double distilled water to make final volume upto 50 ml, that were ultimately used for estimation of minerals, through atomic absorptionspectroscopy (AAS) (AA 800, Perkin-Elmer Germany). Standardsolutions of each mineral viz., Calcium (Ca), sodium (Na), magnesium (Mg) and iron (Fe) were prepared, calibration curves were drawnfor each element, and minerals determined.

Nutraceutical analysis

The total phenolic content of *P. oleracea* samples was determined by modified method of Malick and Singh (1980). The total flavonoids were estimated by Lallianrawna *et*

al., (2013) method and ascorbic acid from fresh leaf samples was assessed by volumetric method of Sadasivam and Theymoli (1987). The β -carotene content was evaluated by Nagata and Yamashita (1992) method and total anthocyanin content was calculated as reported by Rangana (1997).

Antimicrobial assay

For antimicrobial assay, 10g (dried) of *P. oleracea* samples (dried) were extracted with sufficient quantity of three selected solvents (i.e. distilled water, ethanol and methanol) by maceration method at room temperature. The extracts were filtered and concentrated at 40 °C using vacuum evaporator. The dried extracts were then scrapped off and transferred to a tarred wide mouth glass container of appropriate size. Nitrogen was blown in the container before capping and the container was weighed to calculate the yield of each crude extract obtained. The crude extracts so obtained were redissolved in their respective solvents (distilled water, ethanol and methanol) and different concentrations (1mg/ml, 10mg/ml, 20mg/ml and 30 mg/ml) of each extract were prepared for determination of their antibacterial activity. The test (aqueous, methanolic and ethanolic) extracts were screened for their antibacterial activity against pathogenic *bacteria staphylococcus aureus and E. coli (EPEC)* using the disc diffusion assay (Miles and Amyes, 1996).

Anticancer activity

For evaluation of anticancerous potential of *P. Oleracea*, 100mg of aqueous crude extract was redissolved in 10% DMSO (Dimethylsulphoxide) and test extract used for further investigations. Three cancer cell lines, HL-60 (Human Promyelocytic leukemia), MOLT-4 (Human T-lymphoblastic leukemia) and T47-d (ductal

carcinoma) cultured in RPMI 1640 medium supplemented with 20% FCS, 2mmol/L glutamine, 50 U/ml penicillin and 50µg/ml streptomycin were seeded at a density of 10,000 cells/well in a 36-well plate, and allowed to attach overnight. The cells were thereafter treated with different concentrations (100µg-1000µg) of the test extract and allowed to grow for 48 h. The cytotoxic effect of test extracts was determined by MTT cell viability assay. Assuming 100% viability in control cells, percentage of treated cells viability was calculated as:

$$\text{Percent of viable cells} \\ = (\text{Abs.of treated cells}/\text{Abs.of control cells}) \\ \times 100$$

Statistical analysis

Statistical analysis of data generated in this study was performed by using one way analysis of variance (ANOVA), chi-square and correlation tests. The data was analyzed by using comprehensive statistical package SPSS (Version 20) for windows.

Results and Discussion

Wild medicinal plants are commonly used as vegetables in several parts of the world to maintain health or cure ailments and still represent a milestone for ethno-medicine for the search of new and safer bioactive compounds, and if properly exploited can lead to the development of novel anti-cancerous or antimicrobial therapeutics (Rehman and Adnan, 2018; Ebert *et al.*, 2014; Conti *et al.*, 2019).

P. oleracea a wild medicinal herb has nowadays gained a great deal of attention from nutritionalists and biochemists worldwide, due to its marked nutritional and medicinal potential (Khanam *et al.*, 2019; Chugh *et al.*, 2019).

To best of our knowledge, there is scant data available on nutritional and nutraceutical properties of unexplored *P. oleracea* from Kashmir region. Therefore, the current investigation was carried out to evaluate the nutraceutical, anti-microbial and anti-cancerous potential of *Portulaca oleracea* for its further exploitation as anti-microbial and anti-cancerous agent.

In the present era, there has been much concern to diversify the agriculture system through exploring the possibilities of traditional/underutilized plant resources and promote their utilization as alternate nutritive food crops (Mango *et al.*, 2018). In view of this, in the current study the nutritional profiling of *Portulaca oleracea* revealed that there exists a great deal of variation in the nutritional composition of fresh and dried samples, with dried form exhibiting much more nutritional superiority (Table 1). In this study, the moisture content of fresh *Portulaca oleracea* was observed to be $90.70 \pm 0.012\%$, and on drying it got reduced to $8.06 \pm 0.088\%$ (82% decrease).

The ash content of fresh *Portulaca oleracea* was found to be $2.02 \pm 0.009\%$ and increased (60%) to $5.16 \pm 0.145\%$ on drying. The total carbohydrate content of fresh *P. oleracea* was observed to be $3.2 \pm 0.058\%$ that increased (21.9%) to $25.1 \pm 0.173\%$ on drying. The fresh *P. oleracea* was also found to contain $1.80 \pm 0.009\%$, $1.72 \pm 0.020\%$ and $0.08 \pm 0.015\%$ total sugars, reducing sugars and non-reducing sugars, respectively with an increase of 1.76%, 1.44% and 0.32% on drying.

The crude protein content of dried *P. oleracea* was found to be $19.83 \pm 0.145\%$ that was 17.68% higher than fresh samples ($2.15 \pm 0.009\%$). Similar trend was also found for crude fat content that increased to $4.02 \pm 0.011\%$ on drying. Likewise, crude fiber content of dried *P. oleracea* was found to be

6.98% higher as compared to fresh *P. oleracea*. These results thus indicate an exceptionally high nutritional value of *Portulaca oleracea* in its dried form. These results are in strong agreement with the previous reports of Abbasi *et al.*, 2015, Abd-EL-Aziz *et al.*, 2014 and EL-Hadidy *et al.*, 2014. The high nutritional value of this crop indicates that it should be recommended as alternate source of diet and can play a beneficial role to human health, especially for the treatment of nutritional deficiencies.

Mineral elements play numerous beneficial roles due to their direct or indirect effects in human metabolism. Their deficiencies or insufficient intake can lead to several dysfunctions and diseases in humans. Studies have indicated widespread occurrence of deficiencies for mineral elements such as anaemia for iron and osteoporosis for calcium in most developing countries as well as developed world (Gonmei and Toteja, 2018). Thus, it is necessary to screen the foods rich in such micronutrients and incorporate such crops in our diets to prevent the occurrence of their deficiencies especially in poor sections of societies.

Therefore, in the current study, the mineral profiling (in terms of calcium, iron, magnesium, sodium) of fresh as well as dried *P. oleracea* was also performed and was found to be quite variable (Table 2). The fresh *P. oleracea* was found to contain 2.30 ± 0.009 mg/100g iron, 50.06 ± 0.088 mg/100g sodium, 68.40 ± 0.153 mg/100 g calcium and 65.30 ± 0.058 mg/100 g magnesium. Interestingly, the subsequent mineral content of dried samples increased drastically to 47.66 ± 0.088 mg/100g in case of iron, 153.63 ± 0.145 mg/100g, 1366.66 ± 0.120 mg/100g and 943.93 ± 0.713 mg/100g for sodium, calcium and magnesium respectively. These results clearly indicated that dried *P. oleracea* possesses higher concentration of

these vital minerals than fresh samples. The results of this study are in accordance with the earlier findings that report an increase in mineral contents of leaves after shade-drying (El-Hadidy *et al.*, 2014, USDA national nutrient data, 2016; Joshi & Mehta, 2010).

Wild plants are reported to be rich source of bioactive compounds or secondary metabolites that can act either individually or synergistically to maintain health and combat against various oxidative stress related diseases (Fatima *et al.*, 2020). There is a renewed interest to find new and safe anti-oxidant agents from natural sources including plant foods. In addition to phenols, plants have been reported to contain different levels of numerous antioxidants.

In this study it was observed that there exists a significant variation in the concentration of various bioactive nutraceutical constituents (in terms of total phenols, total flavonoids, β -carotene, ascorbic acid and anthocyanins) among the fresh and dried *P. oleracea* samples. As far as phenolic compounds are concerned, they are antimicrobial agents and found ubiquitously in these plant-based foods. Their dietary intake have been described to greatly lower the incidence of various chronic degenerative diseases, such as cancer, diabetes etc and thus the exploitation of foods rich in such phenolics will be quite beneficial (Showkat *et al.*, 2020).

Extensive research studies on functioning and role of polyphenols, their dietary sources and health beneficial properties are being explored aggressively in today's world. As evident from table 3, the total phenol content of fresh *P. oleracea* was found to be 131.46 ± 0.260 mg/100g, that got increased to 385.96 ± 0.744 mg/100g on drying, and thus indicated almost 65.9% increase in this constituent on drying. The total phenolic content of fresh *P. oleracea* observed in this study lies in parallel

to the values reported by Lim and Quah (2007) and are slightly lower as reported by El Kashef *et al.*, (2018). However in dried sample, it was observed that there exists a significant increase ($p \leq 0.01$) in total phenolic content ($385.96 \pm 0.744 \text{mg}/100\text{g}$) that is in close proximity to the findings of Abd-EL-Aziz *et al.*, (2014), but lower than as reported by Dugawale *et al.*, (2019). Polyphenols actually represents a diverse group of compounds and among them, flavonoids are widely distributed and are present in most plant tissues.

In humans, several health beneficial properties of dietary flavonoids are recognized for their anti-oxidant, anti-diabetic and anti-proliferative effects which may protect body from various oxidative stress related diseases (Panche *et al.*, 2016). Flavonoids of underutilized crops including *Portulaca oleracea* have been negligibly identified or studied.

Therefore considering their diverse role, in the present investigation, the total flavonoid content of fresh samples of *P. oleracea* was found to be $6.05 \pm 0.020 \text{mg}/100\text{g}$ that got increased to $98.66 \pm 0.120 \text{mg}/100\text{g}$ on drying and represent almost 93.8% increase on drying. These values obtained are much lower as reported by Silva and Carvalho (2014) in *P. oleracea* plant parts from two different locations in Portugal.

However, these finding are in contradiction to findings of Youssef and Moktar (2014) who suggest decrease in total flavonoid content on drying. Yet another sub group of phenols, anthocyanins are water soluble vacuolar pigments that may appear red, blue or purple depending upon pH. They are responsible for the coloration in flowers and have strong antioxidant role against reactive oxygen species (Qiu *et al.*, 2016). The anthocyanin content of dried *P. oleracea*

($881.76 \pm 0.088 \text{mg}/100\text{g}$) was also observed to be almost 68.8% higher as compared to fresh *P. oleracea* ($274.83 \pm 0.176 \text{mg}/100\text{g}$) (Silva and Carvalho, 2014). Ascorbic acid is the main compound contributing to antioxidant activity of green leaves and fruits (Khan *et al.*, 2011).

Similarly, β -carotene (pro-vitamin A) is an essential nutrient with a number of health promoting effects involved in the regulation and promotion of growth and differentiation of many cells, especially in the eyes and lungs (Olsen *et al.*, 2015). It was observed that β -carotene and ascorbic acid content of dried *P. oleracea* got drastically decreased on drying. The dried samples contain only $14.63 \pm 0.294 \text{mg}/100\text{g}$ β -carotene and $19.60 \pm 0.115 \text{mg}/100\text{g}$ ascorbic acid content as compared to fresh *P. oleracea* that contain $17.04 \pm 0.026 \text{mg}/100\text{g}$ and $23.66 \pm 0.120 \text{mg}/100\text{g}$ respectively.

These results indicated almost 14.1% decrease in β -carotene content and 17.1% decrease in ascorbic acid on drying *P. oleracea* samples. These results are opposed by the findings of Joshi & Mehta, (2010) who reported higher retention of β -carotene on shade drying of drumstick leaves. However our results are in strong agreement with the observations of Gupta *et al.*, (2013) who reported only 1-14% retention of vitamin C and 26-61% retention of beta carotene on drying as compared to fresh *Amaranthus gangetil*, *Chenopodium album*, *Centella asiatica*, *Amaranthus tricolor* and *Trigonella foenumgreecum* samples.

Numerous scientific studies have shown that plants have a high potential to synthesize different antimicrobial substances or compounds including phenols and flavonoids which act as plant defence mechanisms and protect them against various abiotic and biotic stresses (Erdem *et al.*, 2015).

Recently, scientists and pharmaceutical industries have considered the medicinal plants rich in such natural antimicrobial substances as a better choice to protect against broad spectrum antibiotic resistant bacteria.

Therefore, in this study, the antibacterial activities of methanolic, ethanolic and aqueous extracts of *P. oleracea* in terms of zones of growth inhibitions (mm) were evaluated against two pathogenic bacteria (*staphylococcus aureus* and *E. coli* EPEC) and one reference negative control (*E. coli* DH5- α). The common antibiotic Kanamycin (20 μ g/ml) was used as a positive control for extracts.

As shown in figure 1, both fresh and dried extracts of *P. oleracea* demonstrated antimicrobial activity against the test bacterial strains in a dose dependant manner. However, the dried *P. oleracea* extracts proved to be more potent than fresh *P. oleracea* extracts may be due to high concentration of nutraceuticals. Among the different solvents used, the ethanolic extract of dried *P. oleracea* was found to be the most potent antimicrobial extract (Figure 1 A & 1B).

The non-pathogenic *E.coli* (DH5- α) was the most susceptible bacteria to the extract treatments followed by *E.coli* EPEC and *S.aureus*. The order of antimicrobial potency demonstrated that ethanolic extracts are most potent and the aqueous the least. It is suggested that such plant extracts have a great potential to be exploited against pathogenic microbes for development of antimicrobial agent in ethnomedicine (Peng *et al.*, 2014; Bakkiyaraj *et al.*, 2011; Wasnik and Tumane, 2014; Lodankar and Nayaka, 2011; Dhole, 2011).

Exploitation of plants rich in bioactive nutraceutical based constituents and their inclusion in our daily diet have been found to

be quite beneficial for cancer prevention and treatment, as they have been described to block or inhibit the proliferative integrity of individual cancer cells under cell cultured conditions (Al-Hasawi *et al.*, 2018, Fatima *et al.*, 2020). In the current study, the aqueous extract of dried *P. oleracea* demonstrated remarkable anti proliferative potential against three cancer cell lines (HL-60, MOLT-4 and T47-d) after 24 and 48 hours of treatment (Table 4).

It was found that with an increase in the dose there was higher decline in proliferation and the effect was therefore dose dependent. At 100 μ g/ml extract concentration only least cytotoxic effect was observed and most of the HL-60 (95.1 \pm 0.11%), MOLT-4 (99.9 \pm 0.23%) and T47-d (96.13 \pm 0.17%) were found to be viable.

However, the viability decreased drastically while increasing the concentration of the extract (Figure 2). The highest concentration of extract used in this study (1000 μ g/ml) reduced cell viability to 50.9 \pm 0.54% in case of HL-60 cell line, 58.5 \pm 0.28% in MOLT-4 and 60.5 \pm 0.11% in case of T47-d cells. The *P. oleracea* extract was found to acts in a dose and time dependent manner.

As shown in figure 2, at 700, 800, and 900 μ g/ml concentration, 40% or more cells died. The 1000 μ g/ml of *P. oleracea* extract induced the highest cytotoxicity in HeLa cell line followed by MOLT-4 and T47-d cells respectively after 24 and 48 hours ($P < 0.001$) of treatment.

The results of current study are in strong agreement with the earlier reports that indicate anti-proliferative potential and cytotoxic activity of different extracts of *Portulaca oleracea* against various cancer cell lines, (Zakaria *et al.*, 2013; Hassan *et al.*, 2014; Chen *et al.*, 2010).

Table.1 Comparative analysis of proximate composition of fresh and dried *Portulaca oleracea*

Sample	Moisture (%)	Ash (%)	Total carbohydrate (%)	Crude fat (%)	Crude protein (%)	Crude fiber(%)	Total Soluble sugars (%)	Reducing Sugars (%)	Non Reducing sugars(%)
Fresh <i>Portulaca oleracea</i>	90.70 ±0.012	2.02 ±0.009	3.20 ±0.058	0.19 ±0.006	2.15 ±0.009	1.21 ±0.012	1.80 ±0.006	1.70 ±0.020	0.10 ±0.015
Dried <i>Portulaca oleracea</i>	8.06 ±0.088	5.16 ±0.145	25.10 ±0.173	4.02 ±0.011	19.83 ±0.145	7.19 ±0.017	3.56 ±0.012	3.16 ±0.012	0.40 ±0.023
T_{cal}	929.04**	21.57**	119.95**	296.67**	287.26**	287.26**	136.32**	88.18**	11.55**

Results are expressed as mean±SE and are the average of triplicates ** indicates significance level of p≤0.01

Table.2 Comparative analysis of mineral content of fresh and dried samples of *Portulaca oleracea*

Parameter	Fresh	Dried	T _{cal}
Iron	2.30±0.009	47.66±0.088	511.78**
Sodium	50.06 ±0.088	153.63 ± 0.145	609.33**
Calcium	68.40±0.153	1366.66±0.120	6679.52**
Magnesium	65.30 ± 0.058	943.93 ± 0.713	1228.99**

Results are expressed as mean±SE and are the average of triplicates ** indicates significance level of p≤0.01

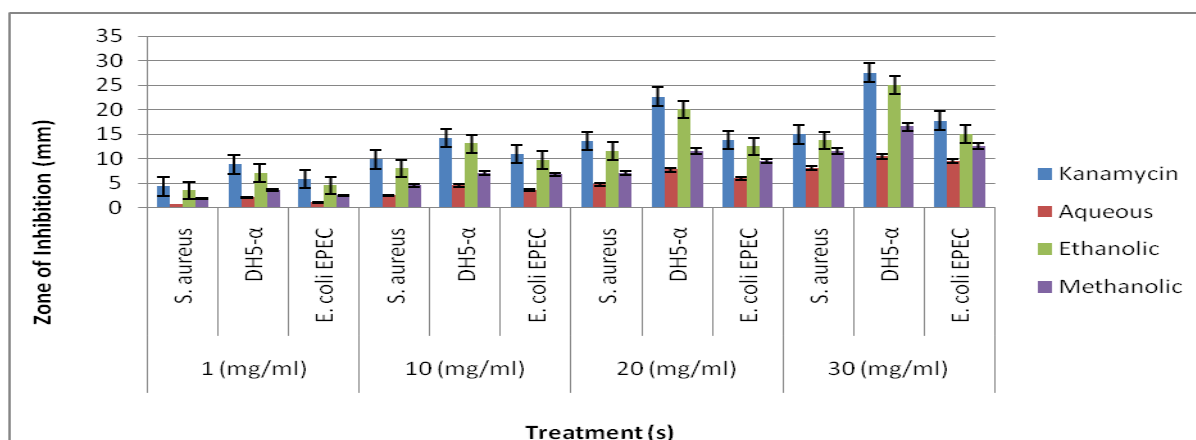
Table.3 Comparative analysis of bioactive constituents of *Portulaca oleracea*

Parameter	Fresh	Dried	T _{cal}
Total phenols (mg/100g)	131.46±0.260	385.96±0.744	958.07**
Total flavonoids (mg/100g)	6.05±0.020	98.66±0.120	759.82**
β-carotene (mg/100g)	17.04±0.026	14.63±0.294	8.141**
Ascorbic acid (mg/100g)	23.66±0.120	19.60±0.115	24.40**
Anthocyanins (mg/100g)	274.83±0.176	881.76±0.088	3077.71**

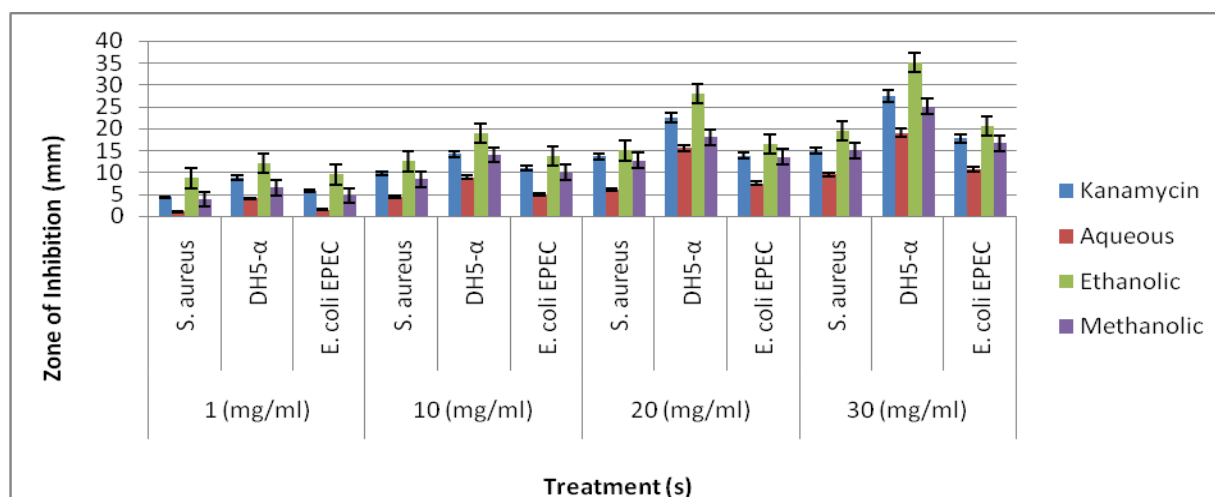
Results are expressed as mean±SE and are the average of triplicates ** indicates significance level of p≤0.01

Table.4 Cytotoxicity activity of dried *Portulaca oleracea* aqueous extract against MOLT-4, T47-d and Hela cells

Extract Concentration (µg/ml)	% Cell Viability		
	HeLa	MOLT-4	T47-d
100	95.1±0.11	99.9±0.23	96.13±0.17
200	90.1±0.17	99.8±0.05	92.06±0.26
300	85.3±0.11	99.2±0.28	88.13±0.14
400	80.5±0.19	97.5±0.19	84.20±0.23
500	75.6±0.23	93.7±0.21	80.16±0.26
600	70.7±0.15	87.4±0.28	70.06±0.15
700	65.9±0.20	79.2±0.20	72.1±0.20
800	61.0±0.14	70.0±0.22	68.4±0.17
900	56.4±0.21	62.7±0.23	64.4±0.18
1000	50.9±0.54	58.5±0.28	60.5±0.11



(A)



(B)

Figure.1 Zones of growth inhibition (mm) of three bacterial strains in response to (A) Fresh and (B) Dried *P. oleracea* extracts at different concentrations

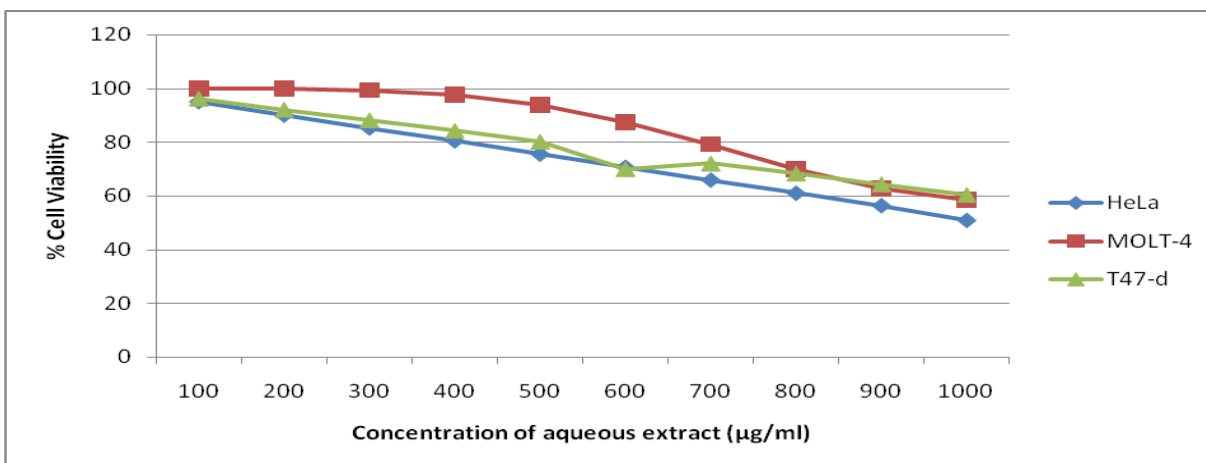


Figure.2 Relationship of percent cell viability of HeLa, MOLT-4 and T47-d cells with different concentrations of aqueous extracts (48hr)

It is suggested that the better antiproliferative property of aqueous extract of dried *P. oleracea* extract may be attributed to higher concentration of bioactive nutraceutical compounds present in it as compared to fresh samples (Lim *et al.*, 2007). Thus from these results we suggest that aqueous extract of dried *P. oleracea* can be better exploited for its anticancer role and the study warrants more research in this direction.

From the current study it can be concluded that *P. oleracea* has an exceptionally high nutritional and nutraceutical value and has great potential especially in its dried form to be further exploited for its antimicrobial and anticancer properties.

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