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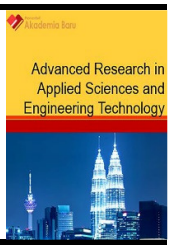

Polyphenol Compounds from Pomegranate (Punica Granatum) Extracted via Various Methods and its Application on Meat and Meat Products: A Review

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Safiullah Jauhar[1], Mohammad Rashedi Ismail-Fitry[1,*], Gun Hean Chong[1], Mahmud Ab Rashid Nor-Khaizura[2], Wan Zunairah Wan Ibadullah[2]

[1] Department of Food Technology, Faculty of Food Science and Technology, Universiti Putra Malaysia, 43400, Serdang, Selangor, Malaysia
[2] Department of Food Science, Faculty of Food Science and Technology, Universiti Putra Malaysia, 43400, Serdang, Selangor, Malaysia

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ABSTRACT

Recently natural polyphenol compounds (PCs) of plants, gained wide consideration of scientists, companies and public people because of its unique pharmaceutical and preservative benefits in the physiological system. They can prevent mortal and serious diseases such as cancer, cardiovascular and Alzheimer. However, defining a suitable source of PCs and their proper, economic and efficient extraction method are still a challenge. The aim of this study was to review PCs as an important antioxidant, the significance of pomegranate as a source of natural PCs and its application in meat and meat product. This study also covers different types of PCs extraction methods such as solid-liquid extraction (SLE) method as a conventional extraction which using Soxhlet apparatus and several solvents and advanced methods such as microwave-assisted extraction (MAE), supercritical fluid extraction (SFE), accelerated solvent extraction (ASE), ultrasound-assisted extraction (UAE) and high hydrostatic pressure extraction (HHPE). Simple and developed analytical method of PCs is also reviewed in the study. SLE method is an easy and simple method but, it uses lots of chemicals and is not suitable for all kinds of PCs extraction. UAE is using for quick extraction PCs, SFE is green extraction method uses less solvent and have a good result but it needs high technology. ASE method is a proper alternative for Soxhlet extraction method for its quick result. MAE method has high extraction result but is not suitable for some thermolabile PCs. Several parts of pomegranate showed antioxidant and antimicrobial traits for shelf life extension of meat and meat product. Pomegranate peel is the strongest antioxidant followed by pomegranate juice and seed. Pomegranate peel prolonged chilled chicken meat shelf live up to three weeks.

Keywords:
Antioxidants, polyphenol, extraction methods, pomegranate, meat

1. Introduction

Antioxidant molecules are known as inhibitor substance of oxidation causes cell destroying inside a physiological system including human and different types of foods. Oxidation process produces free

* *Corresponding author.*
E-mail address: Mohammad Rashedi Ismail-Fitry (ismailfitry@upm.edu.my)

radicals which are highly reactive species and contains one or more unpaired electron in its outer shell [1]. Free radicals inside live organisms are reacting during the oxidation process. They can easily react and destroy cells and tissues. Antioxidants prevent spreading reaction by donation of hydrogen radical to other available free radicals and can effectively reduce food lipid oxidation and rancidity without any sensory and nutrition value damage [2]. Plant polyphenols as natural antioxidants are widely used as it showed considerable health benefits such as anti-carcinogenic, anti-microbial, antioxidant, antiviral, antitumor, anti-inflammatory, antipyretic, analgesic characteristics [3].

Recently plant polyphenols compound (natural antioxidant) has achieved remarkable significance for its food conservative traits, free radical scavenging and containing health benefits for several diseases [4-5]. Due to public awareness, health benefits and consumer high demand the international market of polyphenol compound is remarkably increasing, it was estimated $757 million in 2015 and it is predicted to reach $1,121 million by 2022. The high consumption rate of plant-rich of polyphenol compound by patients and elder peoples also had an important role in the global market growing [6]. The use of preservative as food conservation become prevalent and plays a critical role in the food industries. Even though many types of preservatives have been applied for food protection, consumer demands for natural food preservative are still increasing [7].

Meat possesses high water and abundant nutrients on its surface, so it is highly susceptible to microbial spoilage [8]. Generally, meat spoilage occurs through microbial activities and oxidation of meat protein and lipid [9]. There are different ways to prevent microbial and oxidative functions of meat; various chemicals and natural products can be used for reducing meat spoilage. In addition, healthy food free of chemical ingredient and preservation is in demand for consumers in recent years. New and hazardless processing technologies combined with natural antioxidant and antimicrobial have been suggested [9].

Preservatives are divided into artificial and natural. Artificial preservatives are the cause of toxicology and carcinogen. So the companies and consumers are preferring natural antioxidant as a food preservation [2]. Fruit and some plants containing high phenolic compounds are suitable to be used as preservatives or antioxidants. Pomegranate is one of those which presented stronger antioxidant properties among the fruits, all parts of this fruit comprises a high antioxidants concentration. Pomegranate's peel is a decent source of tannins, anthocyanin, and flavonoids [10]. Çam *et al*., [11] reported that pomegranate has high antioxidant traits among many common fruits.

Several methods have been used for the extraction of polyphenol compound from numerous types of plants. Extraction through Soxhlet apparatus with a different polar solvent such as water, methanol, ethanol or ethyl acetate is a conventional method. There are some advanced methods of extraction such as microwave-assisted extraction (MAE), supercritical fluid extraction (SFE), accelerated solvent extraction (ASE), ultrasound-assisted extraction (UAE) and high hydrostatic pressure extraction (HHPE), which showed different quantitative and qualitative results [12]. However, developing a unique standard method for extraction of different types of plants is still challenging. Scientists are trying to find an efficient, cost-effective and eco-friendly method for polyphenol extraction [4].

This study aims to review the importance of polyphenol as food and health benefited antioxidant, the significance of pomegranate as a strong antioxidant against autoxidation inside the biological system, application of pomegranate phenolic extracts on meat and meat products and different types of simple and advanced polyphenol extraction methods, to provide useful information for relevant research and companies.

2. Literature review

2.1 Polyphenol Compounds

Polyphenols compounds are secondary metabolites which have been widely used as antioxidants; especially for oxidative and microbial spoilage prevention, there are more than 8000 phenolic compounds around the world [13]. Plant-derived polyphenols are secondary metabolites being existed naturally through Shikimate/phenylpropanoid pathway to cope with biotic and abiotic environmental stress, such as temperature, pathogens, and several other factors. Meaning of phenol in chemistry is phenyl ring bearing one or more hydroxyl group [14].

Recently, working on polyphenols compound extraction fascinated attention as a natural product because of its distinct importance. The attention could be justified as a recognized capacity of this compound for scavenging free radicals which are causes of abundant diseases [5]. Polyphenol compounds could be found in abundant plants such as fruits, vegetables, and herbs. Among plants, the fruits are recognized as a leading source of phenolic compounds for example peaches, cherries, apples, plums, citrus fruit, apricots, berries, grapes and tropical fruits [15]. Polyphenol compound can be found in different types of vegetables such as soybeans, carrots, olives, capers, tomato, bean, artichoke, cauliflower, broccoli, spinach and onions [16-19]. There are other significant sources of phenolic in different types of beverages, for example, coffee, beer, black and green tea, cocoa, grains, nuts and fruit juices grains and nuts [17-20]. Also, there are different herbs and spices which have a high level of polyphenols, for example, turmeric, celery, parsley, mint, rosemary, thyme, curry, ginger, clove bud, sage and dill [17-19, 21].

Phenols are normally soluble in polar organic solvents; the glycoside phenols are water soluble. By increasing hydroxyl group water solubility is increasing. Some phenolic are soluble in sodium carbonate and sodium hydroxide. Phenol with a few hydroxyl groups is soluble in ether, chloroform, ethyl acetate, methanol, and ethanol. Methanol, ethanol, water, alcohol are normally used for chemical analysis of phenol [14]. Polyphenol compounds are further divided into several classes such as phenolic acid, polyphenols, flavonoids, lignans, stilbenes and tannins [18].

2.2 Pomegranate

Pomegranate is related to Punicaceae family [22]. Some recent studies propose reassessment on its taxonomy to place it in Lythraceae family. Pomegranate is related to Rodidae subclass, Myrtales order and Punica genus, the pomegranate is unlike other plants has only two species granatum or Lythraceae and protopunica. The Punica protopunica species is only found in Socotra island of Arabian Peninsula. Punica granatum means seeded apple which is derived from Pommum (apple) and grantus (grainy) [23]. A different region named pomegranate and has more than 500 cultivars, in some places, there is a different name for same basic genotype cultivars [24]. Pomegranate has a small tree and included in shrub category, the pomegranate is evergreen in the tropics and is deciduous in a subtropical climate. The pomegranate plant is deciduous and has small, narrow, oblong leaves and short stems. This plant has granular fruit, with green/red of white skin, each grain contains juice which is covered by a smooth membrane [22].

2.2.1 Health benefits and medicinal use of pomegranate

Medicinal using of pomegranate has a long history; different parts of pomegranate were used for several diseases treatments. Pomegranate root extracts full of tannin were used by ancient Egyptian to release tapeworms from human intestines. Hippocrates treat abundant disease through

pomegranate extracts such as digestion problems, reducing skin and eye inflammation [24]. Phytochemicals of pomegranate were used as a pharmaceutical, pharmacological and medicinal bioactivities to heal anti-diarrheal, helminthic, anti-diabetic, antibacterial, anticancer, anti-neoplastic, antiviral, antioxidant, hypolipidemic, digestive and vascular protection [23]. He points out some phytochemicals such as flavonoids, alkaloids, tannins, organic acids, steroids, and triterpenes. According to Smith (2014) recent research of pomegranate suggests different parts of pomegranate for healing several diseases for example diabetes, cardiovascular disease, male infertility, Alzheimer, infant brain ischemia, erectile dysfunction, dental conditions, cancer, obesity, protection from UV radiation and arthritis. According to Table 1 different parts of pomegranate (juice, seed oil, peel, leaves, flower, bark, and roots) has several constituents of chemical sources, which are important for human health [25]. Akhtar *et al*., [26] reported that data from the literature indicate 124 different phytochemicals which can be found in pomegranate fruit; among these phytochemicals, high molecular weight polyphenols (e.g. ellagitannins and the pomegranate-peculiar punicalagin) are likely to mediate the protective effects against a wide range of oxidative and inflammatory disorders, including cancer [22].

Table 1
Pomegranate ingredients from its different sources

Pomegranate parts	Ingredients
Peel and pericarp	Anthocyanidins, phenolic punicalagins, gallic acid, catechin, flavones, flavonones.
Juice	Rutin, quecertin ,anthocyanins, glucose, ascorbic acid, ellagic acid, gallic acid, catechin, minerals, amino acids,
Seed oil	Sterols, ellagic acid, , 95% punicic acid
Flowers	Gallic acid, urosolic acid, triterpenoids including maslinic and Asiatic acid
Roots and bark	Piperidie alkaloids, Ellagitannins, punicalin and punicalagin
Leaves	Apigenin, Tannins, flavone glycosides, luteolin,

2.2.2 Pomegranate peel polyphenol compounds

The pomegranate peel might be considered as the major source of natural antioxidant and its extract possess a relatively high antioxidant activity [27]. Due to a high of its healing characteristic, pomegranate peel has been used since ancient time for several diseases. In addition to its healing value, it also has high nutrition importance which includes vitamins A, B6, C, E, folate, potassium and oxalic acid. In recent years more medicinal values of pomegranate peel have been investigated such as abortifacient, analgesic, anti-amoebic, antibacterial, anticonvulsant, antifungal, antimalarial, anti-mutagenic, antiviral, antispasmodic, diuretic, hypoglycemic, hypothermic, and antioxidant activities [28].

Li *et al*., [29] argued that pomegranate peel accounts for about 50% of fruit weight is characterized by the presence of 63 high molecular weight phenolic, ellagitannins, proanthocyanidins, complex polysaccharides, flavonoids and appreciable quantities of microelements that on the whole, exhibit strong anti-mutagenic, antioxidant, antimicrobial and apoptotic properties.

2.3 Polyphenol Extraction Methods

There are several types of polyphenol compound extraction methods. According to the nature of the plant and effective antioxidant activity, different methods can be used; it can be divided into simple or usual methods and advanced methods with the help of modern technology. The simple methods included solid-liquid extraction (SLE) and heat reflux extraction. Advanced methods of extraction are: ultrasound-assisted extraction (UAE), microwave-assisted extraction (MAE), supercritical fluid extraction (SFE), accelerated solvent extraction (ASE) and high hydrostatic pressure extraction (HHPE) [12].

Xu *et al*. [12] concluded that SLE is a simple and easy method but it needs chemicals and has low efficiency. SFE is an environmentally friendly extraction method but some demotivation factors for this method are required high expenses for investment and it might be not suitable for some polar polyphenol compounds extraction. In SFE method, normally, a supercritical CO^2 liquid is used but because of the non-polarity trait of this substance, some polar fluids such as ethane, butane, pentane, nitrous oxide, ammonia, trifluoromethane, and water are also used.

Due to highly selectivity, highly extractive rate and low critical point the SFE is the remarkable alternative for the extraction of natural thermosensitive bioactive compounds, which does not generate toxic residues [30].

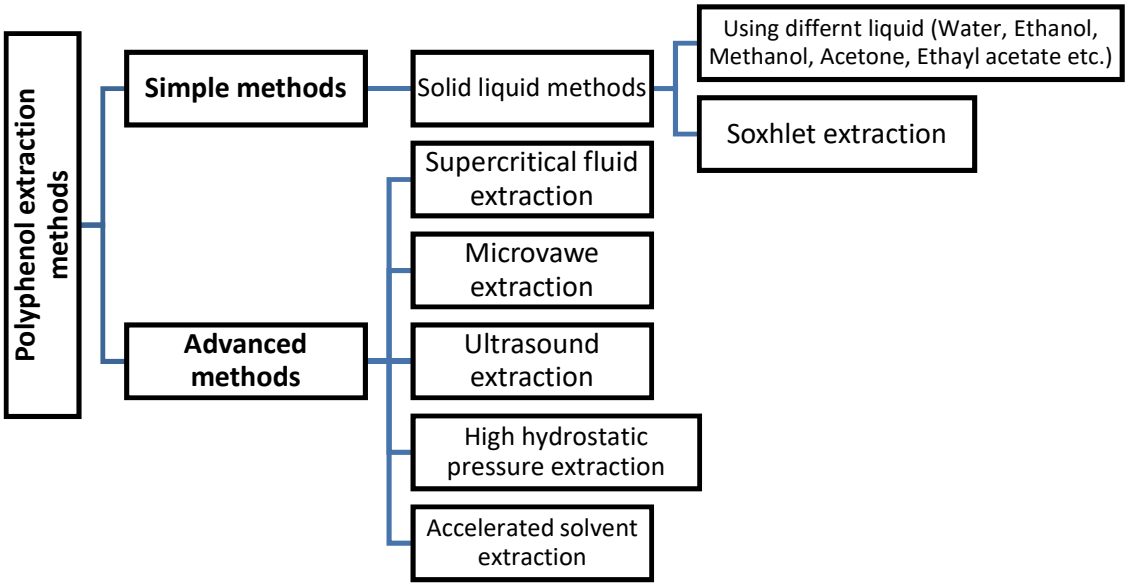

Fig.1. Different polyphenol extraction methods

2.3.1 Solid-liquid extraction method (SLE)

Solid-liquid extraction is a simple method which has been used for a long time. It does not need modern technology and can be conducted easily through simple tools. In this method, different types of polar solvent can be used to extract target ingredients of a substance. Polar solvents such as methanol, ethanol, acetone, chloroform and ethyl acetate are generally used for solid-liquid extraction of polyphenol compound. Extraction without using water showed different antioxidant activities and different amount of yield but by using water for extraction of dried pomegranate peel

extract with ethyl acetate, acetone and methanol exhibited higher antioxidant activities. Methanol has higher polarity then other solvents, the phenolic result of this solvent showed higher antioxidant activity [31]. There are some important variables in SLE method which are necessary to be considered. The solvents such as ethanol, methanol, water or ethyl acetate are strongly depended on contact time, stirring, and temperature [32]. Al-Rawahi *et al*., [33] concluded that in comparison of different extraction methods; methanol extraction of pomegranate peels exhibited a higher capacity for extracting phenolic compounds than water and ethanol. However, some researchers preferred ethanol extraction because it is safe and help water to be evaporated [34]. Masci *et al*. [35] evaluated several extraction methods and they extracted good yields of the polyphenolic compound of pomegranate peel by using Soxhlet apparatus with ethyl acetate for 6 h. For antioxidant activity they resulted in polyphenol extracted from ethyl acetate and Soxhlet extraction methods has the same antioxidant activities but these methods showed stronger antioxidant activities among others.

The solid-liquid extraction method is a simple method which can be implemented without developed technology. Using liquid the methanol yielded a high amount of polyphenol compound but if it remained, the compound inside the product will be harmful to the health of humans and animal. Ethanol or ethyl acetate is preferred by producing a good yield and antioxidant activities. Using ethyl acetate in Soxhlet might be preferred because this method resulted in high phenolic contents and good antioxidant activities.

2.3.2 Supercritical Fluid Extraction method

One of the advanced environmental friendly extraction methods for solid or liquid substance is Supercritical Fluid Extraction (SFE) method, desirable separation of components can be extracted through this analytical technique [36]. This method produces solvent between vapour and liquid phase, through temperature and pressure conditions. By this situation physical changes accruing inside the solvent such as diffusivity, compressibility, gas-like viscosity, liquid-like densities and reduction in surface tension. However, several extraction solvents have been used for SFE methods such as sulfur hexafluoride, fluoroform, ammonia, n-pentane, propane, ethane, nitrous oxide and water, but the most commonly used extraction solvent is carbon dioxide [37].

Pinelo *et al*. [5] used CO^2 as extraction solvents for its economical, non-toxic value and a volatile solvent, which have the modest critical condition. Using ethanol as a co-solvent with CO^2 resulted in high extraction of polyphenols than pure carbon dioxide because CO^2 is not a polar solvent and ethanol has high polarity. The efficient extraction was correlated with temperature (40-60°C) and pressure (10-30mPa). Although peak polyphenols were extracted at 60°C and 10MPa [38]. Selectivity of SFE method is more than other extraction methods, also the production of a less toxic product is another merit of this technique but, the main disadvantage is, it is not applicable to polar solvent and it needs more investment than other methods [12]. Cavalcanti et al. [30] stated that 50°C and 30 MPa is the most operational condition it yielded high phenolic compound and is economic for manufacturing uses of pomegranate leaves phenolic extraction. Mushtaq et al., [39] claimed that there are some important variables which highly influence extraction of phenolic or other antioxidants from pomegranate peel such as incubation time, pH, temperature, enzyme concentration.

2.3.3 Ultrasound-assisted extractions (UAE)

The wave sound of ultrasound is produced by rarefaction and compression process which produces high frequency 2 MHz or greater sound [40]. The ultrasound-assisted extraction method is

derived from ultrasonic processing technology which has been used in the food industry as a novel and promising technology. It has several chemical and physical effects for improving efficiency in food processing operations. This technology is also used as a diagnostic technology for the food quality control process. UAE method is economic and beneficial technology which does not need expensive equipment. It provides sonication in food extraction process, which is produced through sound waves and generates cavitation bubbles near the sample tissue, so it disrupts plant cell walls and releasing its cell contents [41].

There are some variables which have an influence on extraction efficiency such as sonication time, ultrasonic wave frequency, the property of the solvent and temperature [12]. Cheng *et al*., [41] stated that cavitation is very important variable because additionally to the production of cavitation bubbles it does a microstreaming as well. The main advantages of this method can be summarized as it is easy to be used and simple, at mild/low temperature the extraction yield and rapid extraction of heat sensitive ingredients are increasing, it needs less time for extraction process in comparison to conventional extraction methods such as Soxhlet, it needs less equipment and also it is an economic method. The main disadvantages are: in dynamic extraction, the dilution of the extract is not possible, high ultrasound wave causes harmful effects for active ingredients and undesirable changes [4]–[40],[12]. Comparison of UAE and Soxhlet extraction methods of pomegranate peel showed that UAE method has qualitative and quantitative results. Extracts were varied in Soxhlet extraction and UAE methods from 1.82 to 4.0 and 2.45 to 4.49 mg gallic acid equivalent (GAE) / g respectively. The DPPH radical scavenging activity was varied from 15 to 56.02% and 51.84 to 67.94% inhibition in Soxhlet extraction and UAE respectively [42].

2.3.4 Microwave-assisted extraction (MAE)

Microwave-assisted extraction is another advanced method which is widely used for extraction of polyphenol compound from different types of plants. It analyses the sample directly through microwave energy [43]. The wave's microwaves have 1m to 1 mm lengths range, which is equal to 300 MHz (0.3 GHz) to 300 GHz frequencies and produces through the radio. Polar molecules are warm up by this wavelengths through the double mechanism of dipole rotation and ionic conduction [40]. Important variables of MAE method are extraction time, solvent property, dielectric constant, microwave power and solubility. The solvent property is an important variable because more microwave energy can be absorbed by the high dielectric solvent. Generally, water, ethanol, and methanol are using for polyphenol extraction [43].

The MAE process is started through the generation of the electromagnetic wave from a cavity called magnetron. It is continued with the interaction between tissue cell wall, matrix inside the plant and emitted radiation waves and moisture inside plant matrix will be heating up due to absorption of characteristic photonic energy of electromagnetic waves. Evaporation of the plant matrix is started through electromagnetic energy; therefore remarkable pressure applies to cell walls of the plant at subcellular and cellular levels, so plant swelling is started during the process. A structural change occurs inside plant matrix and by interrupting plant cell wall increases in the mass moving of solutes thus, phytochemical are leaching from the cellular matrix of the plant [4]. Merits of this method are: it uses less extraction solvent, the extracted PCs through this method showed high antioxidant activity and need short time for extraction. This method is not applicable to the PCs which have more OH groups and heat sensitive also oxidation of PCs is occurring during this extraction process [12]. Microwave-assisted extraction phenolic yield of pomegranate peel through the water was 210.36 ± 2.85 mg GAE/g and radical scavenging capacity of DPPH was 14.53µg/ml. The optimum condition for

microwave assisted extraction observed to be 1:20 parts of pomegranate peel in water with the 600 W output power in 60 s [44].

2.3.5 Accelerated solvent extraction method (ASE)

Accelerated solvent extraction (ASE) or pressurized liquid extraction is another innovative method which extracts polyphenols of plants through high pressure and temperature. The solvent is rapidly diffusing into plant cells by high pressure and temperature and prevent degradation of polyphenol compound. In comparison to conventional methods, it provides quick extraction and needs a small amount of solvents [45]. In this method, high pressure (3–20 MPa) and high temperature (25–200°C) are used (Watson, 2014). Generally, ASE method is similar to Soxhlet or other conventional method and have the similar results, but it is used to reduce laboratory time and amount of solvent. This method uses high pressure for preventing solvent under its boiling point and slightly high temperature in the extraction process. So, this method is considered as good replacer to old extraction methods [46]. Merits of this method are: target phytochemical can be extracted quickly from solid plant matrix in short time, increase the solubility of solvent and reduce its viscosity in high pressure and temperature and requires the small amount of solvent. The disadvantage is: it needs high pressure and temperature, the requirement of high technology and has no efficiency for extraction of heat sensitive PCs [4, 12, 47], extracted pomegranate peel phenolic by ASE method with ethanol solvent. They identified and quantified individual phenolics, tannins, and anthocyanins by using optimum condition. Ethanol solvent concentration was the most effective factor of extraction. Except for anthocyanins, the optimum extraction condition was the same ranging from 356 to 600 MPa, 32 to 56% ethanol and 30 min extraction time. The optimum condition was 492 MPa of pressure, 30 min of time, and 37% concentration.

2.3.6 High hydrostatic pressure extraction (HHP)

High hydrostatic pressure is another advanced method of extraction which is used for extraction of plant polyphenol compound. The pressure uses in this method facilitate rapid diffusion of solvent into plant cell wall and causes leakage of cell components [48]. HHP extraction method is derived from the high-pressure processing of food, which uses law heat treatment for food processing. This method also has a good result on heat sensitive plants, they will be damaged by the high rate of heating or lose another biological value. The heat-sensitive plants cannot be extracted through traditional method but, its extraction is possible through HHP method. The solvent of HHP method should be selected according to extracting ingredients of the plant because the polarity of the solvents is different [49]. Ferrari *et al*., [50] studied high-pressure effects on the polyphenol and anthocyanin content of several red fruits such as strawberry and wild strawberry mousses and pomegranate juice. They used high pressure optimize condition at 400 MPa, 25 °C for 5 min for pomegranate juice. High pressure in moderate temperature promotes the extractability of coloured pigments and increases the polyphenol content.

2.4 Pomegranate Extracts as Meat, Chicken and Meat Product Preservatives

Physiological functions development of meat and meat products have recently been much considered to develop health and prevent related diseases. Lipid and protein oxidation or generally oxidative changes have been implicated as one of the main factors which reduce the quality and shelf-life of muscle foods [51]. Lipid oxidation or auto-oxidation is one of the major causes of quality

debilitation and reducing the shelf life of meat and meat products. This factor can produce a change in meat quality parameters such as colour, flavour, odour, texture and even nutritional value [52]. Li *et al.*, [12] stated that auto-oxidation is identified for producing aldehydes, ketones, hydrocarbons, esters, furans, and lactones, which could be accountable for rancid flavours and sensory faults during inappropriate meat storage and processing.

Meat industries generally use chemical antioxidants for preservation, to prevent oxidation of meats and meat products. Antioxidants are divided into natural and artificial. The Artificial antioxidants are the cause of toxicology and carcinogen. So the companies and consumers are preferring natural antioxidant as a food preservation [2].

Different parts of pomegranate such as juice, peel and seed are using for reducing oxidation stress inside food or biological system. Pomegranate fruit juice phenolic extracts prolonged chicken meat acceptability level, reduced protein oxidation and microbial growth up to 12 days under 4°C refrigerated storage [54]. Qin *et al*., [55] stated that natural functional ingredients from different parts of pomegranate have the potential to enhance the quality of raw ground pork. The most effective antioxidant is pomegranate peel extract then pomegranate juice extracts and then pomegranate seed extracts. Pomegranate peel has potential to use as a natural product of meat and meat product [56]. Poultry meat dipped in pomegranate fruit juice at 4°C refrigerated condition extended its shelf life to 12 days and reduced oxidative and microbial growth with sensory acceptable [54]. Kanatt *et al*., [57] argue that pomegranate peel has good antioxidant and antimicrobial potential and extend chilled chicken shelf life to 2-3 weeks, also showed high antimicrobial traits but it is not effective in Escherichia coli and S. Typhimurium bacteria. Turgut *et al*., [58] claim that pomegranate peel extract incorporated with meatball reduced protein and lipid oxidation also improve sensory scores and extend shelf life to 8 days in refrigerated storage.

3. Conclusion

Natural polyphenol compound is effective antioxidants which are produced inside several types of plants such as fruit, vegetables, and beverages. Fruits are the main source of phenolic which can provide abundant types of PCs. There are some important antioxidants which can provide inside the human body or other physiological systems, but natural polyphenol compound should be eaten within food or drinks. Pomegranate is the suitable source of PCs, which have the capacity to scavenge free radicals inside the organism and avoid different mortal disease. There are simple and advanced methods of PCs extraction that could be applied to pomegranate. SLE method is an easy and simple method but, it uses lots of chemicals and is not suitable for all kinds of PCs extraction. Methanol extraction of pomegranate peel resulted in high antioxidant activity while water extraction showed a high quantitative result, using Soxhlet apparatus with ethyl acetate showed the suitable result. SFE is green extraction method for phenolic extraction pomegranate, it uses less solvent and has a good and specific result, but it needs high technology. Some factors of SFE method which influence pomegranate phenolic extraction are incubation time, pH, temperature, enzyme concentration. UAE is using for quick extraction PCs and it is simple to use no need for more equipment. This method is effective than Soxhlet extraction method in pomegranate peel phenolics. ASE method is a proper alternative for Soxhlet extraction method for its quick result. MAE method has high extraction result but is not suitable for some thermolabile PCs. The importance of HHP extraction method is that have a good result in heat sensitive plants but need high technology. Different parts of pomegranate showed strong antioxidant capacity and antimicrobial traits for meat and meat product shelf life extension. Pomegranate peel extract is the strongest antioxidant in comparison to pomegranate juice and seed. It extended chilled chicken meat shelf life for up to three weeks.

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