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Utilization of wine industry waste (Grape pomace) in processed meat products: A review

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Abstract
Grape pomace, also called wine pomace, is a by-product of the fruit processing unit of wine industry composed of cell wall compounds, stems and seeds of the fruit. This by-product has attracted the attention of meat food scientists and the meat processing industry due to its high content in nutrients and bioactive compounds. After washing, drying, and milling, a material high in bioactive compounds and fiber is obtained. More recently, research has focused in the production of phenols and making of flours. The most common functions associated with wine pomace products are their use as antioxidants followed by their use as fiber fortifying and antimicrobial agents. These products have mainly been applied to the preparation of meat and fish products to reduce energy load while enhancing fiber and antioxidant contents. The high fiber content of wine pomace and its extracts, however, results in techno-functional interactions that affect physicochemical and sensory properties of meat products. In this article, grape pomace powder and its aqueous and ethanolic extracts along with its application in meat products are discussed.

Keywords: Grapes, wine pomace, antioxidants, meat products

Introduction

Since ancient time, human races are rich in their ethno medicinal wealth of knowledge. While food has long been used to improve health, our knowledge of health is now being used to improve foods [1]. The understanding of relationship between nutrition and health has resulted in the development of concept of functional foods [2]. It clubs the technologically developed ingredients with a specific health benefit [3, 4, 5].

Grape pomace fiber is a rich source of bioactive compounds such as phenolic compounds, polysaccharides, fatty acids, and others [6]. Factors such as variety, culture characteristics, or wine-processing procedures (i.e., time of contact between pomace and grape must during fermentation) may influence grape pomace fiber composition. Usual ranges of DF in these products are 50–75 g/100 g DM [7]. Grape skins are important for the food industry as fiber-rich ingredient; Bravo and Saura-Calixto [8] characterized grape skins from red and white varieties and found a DF content of 54.2 and 59.0 g/100 g DM in red and white skins, respectively. Although data about SDF and IDF content of grape pomace vary, there is no doubt that grape pomace fiber is low in solubility. Owing to the large quantity generated from worldwide wine and grape juice production, grape pomace has the potential to serve as an important IDF source for functional food development [9].

Livestock and meat industry have a great contribution in agrarian economy. India has a huge livestock population and proper utilization of livestock and their products can provide economic and food security to the farmers. Meat is an excellent source of some essential fat soluble vitamins and minerals of high degree of bioavailability. Recent trends of negative campaign about the possible health hazards by meat consumption had changed the consumers' orientation towards functional meat products [10]. The direct relationship between functional diet and plethora of diseases has been further emphasized the search of components that can be regarded as a marker of healthy diet [11, 12, 13]. The popularity and consumption of meat differs within and between communities but consumer's preference of meat is almost universal depending on cultural traditions and social and economic conditions.

Poultry, sheep and goat meat is highly preferred in India. Unlike cara beef, pork and beef consumption, poultry, sheep and goat meat consumption has no religious taboo. Psychological and sensory responses (product appearance, price, aroma, flavour, tenderness, juiciness, nutritive value) play an important role in the acceptance of consumers liking or disliking [14]. Flavour decided the sensory quality of muscle food and ultimately its overall acceptability [15].

Several studies have been done on meat and its chemistry and flavour. Shahidi [16] reported that different meat had an inherent characteristic odour and flavour associated with it. Hornstein and Crowe [17] reported that the fat contribute inherent species specific flavour. In addition, Melton [18] also documented that meat flavour is influenced by fatty acid composition. Jacobson and Koehler [19] named carbonyl as a specific mutton odour imparter.

Oxidation in Meat Products

However, despite of the overwhelming nutritional benefits, lipid is one of the major causes of deterioration of meat and meat products that ultimately resulted into unacceptable color, flavour and odour and rheological properties and several types of disease. The main cause for deterioration is the generation of prooxidants free radicals that induces lipid and protein oxidation during processing and storage of meat leading to further production of toxic chemical and radicals. These include a variety of carbonyl-based cytotoxic and genotoxic compounds known as advanced lipid oxidation end products (ALEs), such as 4-hydroxynonenal (4-HNE) and malonaldehyde (MDA) [20, 21] and carcinogenic nitrosamines in nitrite-cured products [22].

Meat and meat products were more prone to lipid oxidation due to variety of factors including the relatively high proportion of polyunsaturated fatty acids (PUFA) as constituents of membrane phospholipids, the deficiency of endogenous antioxidants, such as tocopherols, in respect to vegetable and other plant oils, high concentrations of pro-oxidants and radical initiators, such as heme species, high concentrations of salt (NaCl) added, and the abundance of molecular oxygen that is usually incorporated into blended meats during processing operations [23].

Lipid peroxidation and oxidative damage in the human body play a major role in developing most oxidative stress-related diseases. It resulted into the imbalance between production of oxidants and the capacity of endogenous antioxidants systems to prevent oxidative damage that occur within the cell. Reactive oxygen species (ROS) such as superoxide anion and hydroxyl radical are among the most important prooxidants generated during the oxidative stress condition. These free radicals affect cell homeostasis, damage to proteins, DNA, and lipids and also play a role in neurological disorders like alzhimer’s disease and atherosclerosis. Although vitamin E is the most important dietary component contributing to natural antioxidant defences in tissues [24] but it is not available in quantity sufficient to retard oxidative damage due to its homogenous nature of tissue. Therefore, nowadays concern towards natural or synthetic antioxidants has been increased. Natural antioxidants are preferred over synthetic ones such as, plant derived product like red grapes, rosemary, mint, tomato, lemon etc.

The lipid oxidation in meat is generally involves either free radicals and/or reactive oxygen species such as singlet oxygen to react with substrates such as unsaturated fatty acids [25]. Cooked meat is more prone to lipid oxidation than its uncooked counterpart during refrigerated storage [26]. Naturally existing cations, such as iron and copper, in meat, are known to act as pro-oxidant catalysts and quenching of such a property play an important role in for the oxidative stability of meats [27]. Heam pigments serve as a source of free iron, being readily broken down during the cooking process and promote auto oxidation leading to rancidity in cooked polyunsaturated fat rich meat. During processing the particle size reduction leads to close contact of catalysts with lipids and introduce oxygen into an anaerobic tissue. Cooking causes disruption of cellular organization in the skeletal muscle tissues, resulting in protein denaturation and loss of antioxidant enzyme activity., Release of protein-bound iron and salting further increases the catalytic activity of iron and reduces antioxidant enzyme activity [28]. These processing operations can markedly increase the lipid oxidation in muscle foods. Therefore, during processing of meat, control of these catalytic systems is very important to minimize lipid oxidation. In foods, including those made from muscle, there is a need to extend the shelf life of the product until it is consumed. The shelf life of processed meat can be extended by using antioxidants and proper packaging materials. Because of the growing consensus on the potential health hazard caused by synthetic antioxidants, there is a renewed interest in the increased use of naturally occurring antioxidants.

Composition of Grape Pomace

Proximate composition of grape pomace (g dry matter per 100 g) is protein 11.0, fat 7.69, ash 5.25, fibre 77.6 and soluble dietary fibre 15.53, insoluble dietary fibre 62.07 [29]. Red pinot noir grape pomace, obtained from white wine processing, was milled to obtain a flour (PF) and further analysed for total protein (13.80 g/100 g), fat (4.21 g/100 g), carbohydrates (19.68 g/100 g), dietary fibre (DF) (51.38 g/100 g) and ash (5.55 g/100 g) [30]. Grape pomace flour had below neutral pH (3.82), moisture (3.33g/100g), acidity (0.64g of citric acid/100g), ash (4.65 g/100g), carbohydrate (29.2g/100 g), protein (8.49g/100g) and lipids (8.16g/100g) per 100 gram, respectively [31]. The total energy was reported to be 224Kcal/100g. With regard to the compounds’ with functional nutritive value, it had vitamin- C and anthocyanins content as 26.25 mg of ascorbic acid /100g and 131mg/100g, respectively.

Total Phenols in Grape Pomace

Phenolics are one of the major groups of compounds acting as primary antioxidants or free radical terminators and it is one of the important parameters to determine the amount of antioxidants. Nowadays, there has been a growing interest in substances exhibiting antioxidant properties, which are supplied to human as food components or as specific preventive pharmaceuticals. Consequently, antioxidants have become an essential part of preservation technology and contemporary health care services. It is well documented fact that anti-oxidative and pharmacological properties of plants are due to the presence of phenolic compounds, especially phenolic acids and flavonoids. Although, phenolic compounds do not have any known nutritional function, they may be important to human health because of their antioxidant potency [32].

Total polyphenols index for High-Low Instantaneous Pressure extract and methanolic extraction were 546.00 and 256.50 mg\l, respectively, by simple distilled water and grape pomace methanolic extraction yielded total 0.06 g/100 g Extracts [33]. In pomace flours, phenolic content varied from 21.63 to 42.38 mg gallic acid/100 g pomace, whilst in lyophilized aqueous extracts, the content varied from 9.76 to 213.08 mg gallic acid/100 g [30]. The total phenolic compounds of Isabel grape residue extract and Niagara grape residue extract were reported 784.25 and 941.66 mg GAE/100g (dry weight), respectively [34]. The values in the

Isabel grape peel extract and Niagara grape peel extract were recorded 854.03 mg GAE/100 g and 1014.04 mg GAE/100 g (dry weight), respectively [35].

Effect of Grape Pomace on Quality of Meat Products

Effect on pH Value

The pH of muscles falls down after slaughter due to production of lactic acid. It has profound effect on functional properties and keeping quality of meat. Addition of non meat ingredients changes the pH of meat products depending upon the source of plant material.

The incorporation of grape powder (1%) in chicken patties had lowered its pH as compared to control samples [36] and addition of grape seed extract even at 0.1% in chicken patties had lowered its pH as compared to control [37]. Selani *et al.* [34] confirmed that pH values of chicken meat incorporated with wine industry residue was slightly lower for cooked samples as compared to raw samples.

Effect on TBARS Value

Oxidation of lipids causes significant decline in organoleptic properties of meat and meat products during storage. Oxidative rancidity is commonly assessed by employing TBA assay. Meat products can be accepted in good preservation condition in respect to oxidative changes if they had less than 3 mg malonaldehyde/kg of sample but in cooked meat product, higher values than 3 mg malonaldehyde/kg was reported that served as an indicator of advanced oxidation state in meat products. In respect to natural antioxidants, the used concentration was sufficient for maintaining the oxidative stability of the chicken product [38].

Addition of grape pomace (1%, w/w) in combination of reduced nitrite levels to the beef sausage samples reduced TBARS content and the degree of lipid oxidation. Antioxidant activity and total phenol contents reference product and rated good to very good for appearance, flavour, juiciness, texture and overall acceptability

The TBARS value of cooked chicken meat incorporated with Isabel grape and Niagara grape residue extract were in the range of 1.66-2.24 and 1.35-2.12 mg malonaldehyde/kg, respectively, whereas control TBARS value was in the range of 4.75-7.71 mg malonaldehyde/kg during storage period of 0 to 9 months [34].

Effect on Sensory Quality

Various qualities like aroma, flavour, colour, appearance, texture, tenderness and juiciness influence the palatability of meat products. With the rapid development of fast foods, especially ready to eat meat products meant for short term storage under refrigeration temperature, flavor as sensory attribute has gained much importance because of oxidative rancidity of meat products.

Addition of Grape Seed Extract (GSE) up to 1000 µg/g did not significantly affect the sensory scores of cooked pork patties for any of the quality attributes tested [40] and GSE was effective in limiting the intensity of warmed over flavour that are commonly associated with oxidative rancidity in precooked meat [41]. Rancid and wet-cardboard odors were also reduced by GSE in cooked beef and pork [42]. Restructured chicken slices incorporated with red grapes powder were acceptable as reference product and rated good to very good for appearance, flavour, juiciness, texture and overall acceptability [36]. Acceptability of beef sausages was not affected by the addition of grape pomace and had relatively greater scores from a sensory point of view [39].

Effect on Instrumental Colour Profile

Colour is an important visual cue involved in consumer perception of acceptable meat quality [43]. GSE addition at levels up to 1000 µg/g did not alter the $L*$ lightness and $b*$ yellowness values of raw pork patties and it resulted in minor increases in $a*$ redness values, relative to controls, after 6, 9 and 12 days of refrigerated storage at 4±1 ^{0}C [40]. But in cooked samples, $L*$ values was decreased and, $a*$ and $b*$ value increased with addition of the grape extracts [34]. The concentration of GSE used in ground chicken breast (0.1%) caused significantly darker ($L*$), redder ($a*$), and less yellow ($b*$) patties [41]. Addition of a grape antioxidant dietary reduction in lightness values (up to 24%), increase in redness values (2.22 times), reduction in the yellowness values relative to controls in cooked chicken hamburgers after 3 and 5 days of refrigerated storage at 4±1 0C [44]. Red grapes extract significantly (P ≤0.05) improved the colour scores compared to control and BHA during refrigerated storage of both aerobic and vacuum packed products. This might be due to inhibition of myoglobin oxidation by GSE, which in turn delay the surface colour deterioration [29]. A significant reduction in lightness ($L*$) and yellowness ($b*$) of systems containing grape pomace was also observed in beef sausage [39].

Effect on Microbial Quality

Addition of grapes seed extract significantly (P≤0.05) reduced the total psychrophilic and coliform counts in restructured mutton slice during refrigerated storage, which might be due to the antimicrobial activity of grapes seed extract [45].

The results obtained from the grape extracts were very promising, especially the activity of the methanolic extract of the seeds (GSD), which were effective against B. cereus ATCC 11778, B. subtilis ATCC 6633 and S. faecalis TISTR 459 (MIC =16 pg/mL). The highest MIC value of 512 jg/rnL for GSK was estimated for E. coli ATCC 29214. The activity of the GSD and GSK against both Gram positive and Gram-negative bacteria may be indicative of the presence of broad-spectrum antibiotic compounds, which are distributed mainly in the seeds and skins of grapes [46]. In addition, in beef sausage samples containing dry red grape powder showed lower microbial count compare to blank sausage [39].

Conclusions

The meat products can be enriched with adequate amount of dietary fiber by wise selection of fiber sources and by method of incorporation. Various sources of antioxidant dietary fiber have been explored by different researchers, which are being attempted in the meat products. These sources markedly enhance the dietary fiber content in meat products and making them more functional as well as healthier. This study demonstrated that wine grape pomace may be utilized as an alternative source of antioxidant dietary fiber to fortify processed meat products for not only increasing dietary fiber but also delaying lipid oxidation of samples during refrigeration storage. These alternatives may also contribute to reduce winery residuals, improve environmental aspects and reduce production costs. Furthermore, the meat industry will be provided with natural products that are able to inhibit different microbiological and chemical reactions, enabling the reduction in the use of synthetic food preservatives and antioxidants without compromising the stability of the final product. Thus it is expected that more acceptable novel meat products with promising health benefits will be available in future.

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