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VEGETABLE DERIVATIVES USED IN MEAT PRODUCTS

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Abstract

Plant derivatives are high biological value products, with sensory properties appreciated by consumers, which are easily obtained, relatively cheap and can be successfully used as meat analogues. Additionally, some plant derivatives result as waste from the vegetable products industry and can be successfully valorized in meat compositions for their content in vitamins, antioxidants, unsaturated fats, minerals or fibers. Consequently, when used in the meat industry, they can improve the structural, sensory and nutritional characteristics of the finished products. Due to their high fiber content, they can be successfully used to increase yields, but also to reduce the potential caloric value of meat products, with positive effects on health. The paper aims to analyze scientific research referring to the use of plant derivatives as meat analogues and their effects.

Key words*: meat products, nutrients, plant derivatives, yield.*

INTRODUCTION

The studies developed in this scientific work started from the hypothesis that plant extracts with a high content of specific phytochemical substances, obtained from various plant materials, will have synergistic antioxidant and antimicrobial effects, will inhibit the growth of pathogenic and spoilage bacteria, the evolution of oxidative processes in various meat products and will improve the quality and safety of meat.
Plant derivatives can be used to improve the technological characteristics of meat, increase yields, improve the rheological properties of meat compositions, and enhance the sensory characteristics of finished products.
Furthermore, it was assumed that incorporating complex plant extracts with antioxidant properties into processed meat products would result in healthier products due to the reduction of oxidation levels in the meat, thus preventing inflammatory reactions without significantly affecting their sensory characteristics.
The main objective of the studies was to improve the functional value of meat products by adding powders and natural extracts with antioxidant properties, as meat is a healthy food product, containing proteins with high biological value, a high content of essential minerals and B-group vitamins. The translation is formal, technical, in paragraphs, detailed, and advanced.
Lipid oxidation represents one of the causes of meat and meat product deterioration as it is accompanied by the appearance of a large number of unwanted changes in flavor, texture, and nutritional value. The speed of lipid oxidation can be effectively reduced by using antioxidants. Synthetic antioxidants have been widely used in the meat industry, but consumer concerns about the safety and toxicity of products have led the food industry to seek natural alternatives.
As a result, some natural ingredients, including herbs and spices, have been studied, especially in Asian countries, as potential antioxidant products in meat and meat products.
Research has shown that natural antioxidants extracted from plants can be used as alternatives to synthetic antioxidants due to their equivalent or even greater effect on inhibiting lipid oxidation. It has been demonstrated that certain compounds from herbs and spices contain many phytochemical substances that have antioxidant, anti-inflammatory, and anticancer activities (Boruzi, 2020).

Currently, consumers are increasingly concerned with all aspects that can contribute to improving the quality of life, and although dietary intake is not the only element that influences well-being and health, it is one of the most important.

The factors that have favored this evolution include the current extremely high impact on public opinion of media reports regarding the relationship between diet and health, the increase in life expectancy of the population, or a heightened attention to disease prevention.

This concept also includes food products known as "functional foods". These are defined as foods that help prevent and treat certain conditions and diseases, in addition to their nutritional value as such.

In fact, this is not a new idea, for centuries humanity has been using the properties of certain foods that provide additional physiological benefits to treat, alleviate or prevent diseases.

RESULTS AND DISCUSSIONS

The influence and effects of natural extract additives on the physico-chemical and sensory characteristics of meat products

Some of the research that has followed the use of plant derivatives in the creation of new meat products is presented in Table 1.

Boruzi (2020) demonstrated that the powder of walnut leaves used as a source of natural antioxidants in pork meatballs had a considerable antioxidant activity.

The study aimed to evaluate the oxidative stability and color stability of ground pork meat containing walnut leaf powder at levels of 0.2% and 0.5% addition, compared to a control without antioxidant addition and a control with 0.1% butylated hydroxytoluene addition.

The results showed that the moisture content was higher in the samples containing walnut leaf powder, indicating that it contributed to the retention of moisture in the product.

The color of the meat depends on the concentration of meat pigments, as well as the physico-chemical properties of the meat substances and those added to it. The addition of walnut leaf powder as a natural antioxidant, with a high content of phenolic compounds, had a significant effect on color stability.

Increasing the storage time resulted in a decrease in the overall acceptability of pork meatballs, with or without additives. However, samples with an addition of 0.5% walnut leaf powder showed higher scores for overall acceptability and flavor compared to the control, as the powder has the potential to reduce oxidative rancidity and extend the shelf life of cooked pork meatballs. Additionally, increasing the amount of walnut leaf powder significantly increased the free radical scavenging activity.

Boruzi (2020) also found that adding cherry stem extract did not significantly affect the brightness and autochthonous microflora activity of the meatballs, but improved the antioxidant activity.

Another natural derivative used for the sensory valorization of pork meat is represented by essential oils.

Mantzourani et al. (2023) studied the use of thyme and oregano essential oils alone or combined with ethanolic extracts of pomegranate in pork meat.

The sensory evaluation of pork loins during storage at 4°C for 7 days, treated with red wine marinade with various combinations of ethanolic extract of pomegranate, as well as essential oils of oregano and thyme, was studied in terms of color, tenderness, flavor, and juiciness.

The study showed that the most intense color was recorded for pork fillets with the addition of pomegranate extract compared to pork fillets marinated with essential oils (oregano and thyme) and red wine, and in terms of tenderness and juiciness, no significant differences were recorded. The sensory impact of marinades on pork fillets was accepted by consumers.

Turgut et al. (2016) found an improvement in the stability of sensory characteristics (color and odor) of beef meatballs in which pomegranate peel extract was added, extending the shelf life by up to 8 days.

Increasing the TVP percentage from 10 to 40% in pork sausages resulted in a decrease in sensory acceptability, with the control sample being the best scored by tasters (Hidayat et al., 2018).

Table 1. Plant derivatives used in meat products

Authors	Product type	Used derivative	Processing conditions	Antioxidant activity	Antimicrobial activity	Sensory properties and functional properties
Boruzi, 2020	Pork meatballs	Extracts from walnut leaves and cherry stems	Treating at 72^0C in the thermal center	The leaves/extracts have increased antioxidant activity comparable to synthetic antioxidants.	Poor	Positive effects; color deterioration is reduced during storage. The flavor has improved. The succulence has increased.
Boruzi, 2020	Pork meat	Powder from walnut leaves, extracts from walnut leaves and cherry stems	Storage, 0-4^0C	-	Significant (does not inhibit bacteria, but a weaker colony growth is observed)	-
Mantzourani et al., 2023	Pork fillets	Thyme essential oil (TEO) and oregano essential oil (OEO) alone or combined with pomegranate extracts.	Treating at 72^0C in the thermal center Storage, 0-4^0C	-	Fewer pathogenic bacteria	Color, tenderness, flavor and juiciness
Turgut et al., 2016	Beef meatballs	Pomegranate peel extract	Refrigerate, 4 ± 1^0C	Significant antioxidant activity	-	The color and smell of staleness have been improved
Biasi et al., 2023	Product Mortadella type.	Blueberry flour	Refrigerate, 0 ± 4^0C	Increased antioxidant activity	-	-
Baune et al., 2022	Burgers and meatballs	Texturized vegetable protein (corn, soy and pea protein)	Baking at 70^0C	-	-	Improved cooking loss, moisture retention, shrinkage, cohesiveness, chewing, elasticity, hardness and cutting resistance
Bakhsh et al., 2021	Beef meatballs		Baking at 70^0C	-	-	A significant reduction in hardness, cohesion, and thickness, but also an increase in dietary fiber content; total moisture and fat content was lower, and water release and cooking losses were reduced
Hidayat et al., 2018	Hybrid sausages	Textured Pumpkin Seed Protein	Treating at 72^0C in the thermal center	-	-	Increased water content due to high retention capacity of TSPS; sensory quality of products decreased
Revilla et al., 2022	Fresh meat from pork pulp; pork back fat	Chickpea protein isolate	Refrigerate, 0 ± 4^0C	-	-	Significantly improves water-fat binding capacity and improves textural properties (hardness, elastic ability and chewing)
Wang et al., 2019	Beef and pork products imitating vegetable protein	8 common edible mushrooms= analogues of meat protein	Treating at 72^0C in the thermal center	-	-	The texture, taste and flavora of the product have been greatly improved
Stephan et al., 2018	Vegetarian sausages	Mushrooms species *P. sapidus*	Treating at 72^0C in the thermal center	-	-	Texture close to traditional sausages, with better sensory value than other vegetable proteins
Patinho et al., 2021	Beef burgers	Mushrooms species *A. bisporus*	Baking at 70^0C	High oxidative stability	-	Good sensory properties, good fragrances

The influence of plant derivatives on lipids and meat pigments oxidation

Boruzi (2020) studied the global antioxidant activity of samples treated with powder and extracts of walnut and cherry stems, which was significantly higher (P<0.05) even compared to samples with added butylated hydroxytoluene and also improved the degree of color deterioration.

After 15 days of storage, the antioxidant activity was significantly higher in samples with added extracts rich in phenolic compounds and walnut leaf powder (with a higher content of flavonoids) compared to control samples with or without butylated hydroxytoluene. The walnut leaf extract showed a higher antioxidant capacity than the cherry stem extract (3.67 mmol/100 g Trolox for walnut leaf extract and 2.84 mmol/100 g Trolox for cherry stem extract). The results showed that an addition of 0.2% walnut leaf powder has a delaying effect on lipid oxidation similar to the addition of 0.1% butylated hydroxytoluene, with positive effects on shelf life.

Turgut et al. (2016) studied the antioxidant effect of pomegranate peel extract on lipid and pigment oxidation in beef meatballs during storage at a temperature of 4 ± 1°C.

The lyophilized extract from pomegranate peel was incorporated into freshly ground beef at concentrations of 0.5% and 1% and compared to a reference control of 0.01% butylated hydroxytoluene and a control with no antioxidant.

It has been demonstrated that in the tests with the addition of pomegranate peel extract, with a high content of phenolic compounds, the value of acid thiobarbituric reactive substances, peroxide formation, loss of sulfhydryl groups, and protein carbonyl formation were lower than the control (P <0.01) after 8 days of storage.

An alternative natural derivative with antioxidant effects is blueberry flour, which has been shown to have superior effects on digestibility, antioxidant capacity, and preservation of mortadella-type products over time. Biasi et al. (2023) found the formation of peroxides on the 7th day of storage in control samples (made from pork), while in samples containing blueberry flour (*Vaccinium corymbosum* L. species), peroxide formation began on the 15th day of storage.

The addition of blueberry flour (0.05%), which has a high concentration of phenolic compounds, mainly chlorogenic acid and isoquercetin, controlled the oxidation of mortadella lipids during storage. Antioxidant activity increased in the intestinal phase with the increase in the concentration of added blueberry flour.

The influence and effects of natural extract additives on microbial activity

Analyzing the effect of damage caused by walnut leaf powder, walnut leaf extract, and cherry stem extract on microbial activity, Boruzi (2020) found that they did not have a bactericidal effect on the studied species, but instead a weaker colony development and selection of microbial genera was observed. Thus, in samples with walnut leaf extract, the lowest microbial load was found, consisting mainly of *Lactobacillus* and *Staphylococcus* genera, in samples with cherry stem extract, *Bacillus cereus* developed mainly, while in those with walnut leaf powder, *Brochothrix thermosphacta* and *Bacillus* spp. developed.

Mantzourani et al. (2023) studied the effect of thyme and oregano essential oils and pomegranate extracts on the microbiological stability of pork meat. The concentration of Enterobacteriaceae and mesophilic bacteria decreased compared to the control when adding wine, oregano essential and thyme essential oil, while there were no statistically significant differences in the concentration of yeasts and molds. On the other hand, the evolution of staphylococci was reduced by the added extracts, indicating a strong antimicrobial effect. Pseudomonas bacteria were affected by the wine and oregano essential oils mixture. The added extracts did not have a negative influence on the organoleptic properties.

The influence of natural plant extracts on the functional properties of meat

Baune et al. (2022) have argued that textured vegetable proteins such as corn and soy blend, pea protein used as an alternative in meat products significantly alter the technological properties of meat.

Due to the strongly varied techno-functional properties of vegetable proteins (such as water and oil binding, gelling capacity, and gel resistance), they can be incorporated into meat products, with dry texturized vegetable protein being less efficient than those with high moisture content. Baune et al. (2022) have shown that a mixture of soy protein isolate, wheat gluten, and starch (ratio 5:4:1) is suitable for obtaining 100% plant-based meatballs.

It has been demonstrated that extrusion conditions have had a significant impact on the properties of meatless meatball, such as loss during cooking, moisture retention, cohesiveness, mixing, elasticity, hardness, and cutting resistance (Samard et al., 2021).

The addition of 10-40% textured vegetable proteins resulted in lower values for cohesiveness and hardness, and an increase in gumminess and chewiness values compared to beef meatballs, while water release and cooking losses were reduced (Bakhsh et al., 2021).

Ebert et al. (2021) analyzed the buffering capacity of pork meat compositions (188 mmol H/kg*ΔpH) compared to wet pea (225 mmol H/kg*ΔpH), pumpkin (333 mmol H/kg*ΔpH), and sunflower (259 mmol H/kg*ΔpH) textures, and found a slight increase in buffering capacity for vegetable textures, possibly related to the increased amount of amino acids with high buffering capacity and mineral residue content.

The water holding capacity slightly increased with the partial replacement of meat with 10-40% textured soy protein in pork sausages. At the same time, the hardness of the samples decreased with the increase in the percentage of added texturized protein (Hidayat et al., 2018). This can be attributed to the improved hydrophilic character of the product due to the high water retention capacity of soy and pea proteins (Hidayat et al., 2018).

Revilla et al., 2022 studied the effect of stability of meat emulsions in which meat was replaced with 25% to 100% of chickpea protein isolate and bacon was replaced with olive oil. They found a reduction in cooking losses ($P < 0.05$) and centrifugation losses up to 50% substitution. Increasing the chickpea protein isolate addition to 100% resulted in increased cooking and centrifugation losses.

The addition of chickpea protein isolate (0.5-2%), as a replacement for polyphosphates, in pork meat products resulted in a decrease in cooking loss of 13.29%, 13.33%, 12.57%, and 0.76% compared to the control group. At the same time, the increase in chickpea protein isolate concentration generated a direct proportional increase in hardness and gumminess, and a decrease in springiness and cohesiveness (Wang et al., 2023). Heating promotes the unfolding of protein conformation and exposure of reactive groups of chickpea protein isolate and meat proteins (Wang et al., 2023), which favors their interactions and the formation of a complex gel network that helps to retain structure, reducing water and fat expulsion during cooking.

The nutritional advantages of natural extracts/protein analogues on meat

Wang et al. (2003) studied the nutritional advantages of edible mushrooms and concluded that they can become a major source for obtaining meat analogues.

Mushrooms are an important source of nutrients, with a high protein content ranging from 18.1-53.7%, and rich in unsaturated and polyunsaturated fatty acids at 17.3-66.7% (reported as total fatty acids). They are also an important source of vitamins (173-782 mg sterols/g dry substance) and minerals at 5-12%, reported as dry substance (Kalač, 2009). Mushrooms are a source of antioxidants such as ascorbic acid, beta-carotene, lycopene, and gamma-tocopherol. The total phenolic content for *Pleurotus ostreatus*, recorded by Chirinang et al. (2009), was 42.47 GAEs/g dry substance. Mushroom proteins are complete proteins, containing all essential amino acids necessary for the human body, some of which have therapeutic effects in treating gastritis, esophageal cancer, diabetes, or hypertension (Kim et al., 2009). Some of the most important varieties in terms of protein quality are *Agaricus bisporus*, *Flamullina velutipes*, *Tricholoma matsutake*, and *Pleurotus eryngii* (Gao et al., 2012; Zhang et al., 2017).

Poddar et al. (2013) studied the effects of consuming white mushrooms and meat on individuals who entered a weight loss program and found a reduction in initial body weight of 3.6% for the group that consumed mushrooms, compared to those who consumed meat, who lost 1.1% of their body weight. Wang et al. (2019) used *Lentinula edodes* as a partial analogue of lean pork to obtain sausages and found that the resulting products had improved physicochemical and sensory properties.

Stephan et al. (2018) made vegetarian sausages from *Pleurotus sapidus*, obtaining products with physicochemical properties similar to traditional sausages, with a similar texture, but with better sensory value than other vegetable proteins. Making beef burgers with 5-15% *Agaricus bisporus* mushrooms to reduce fat content resulted in products with good sensory properties, good tenderness, and high oxidative stability (Patinho et al., 2021).

Soy flour contains an excellent amino acid profile and is widely used as a major indispensable protein in animal industries. This vegetable has a high content of protein (33-49%), fats (15-26%), non-nitrogenous extractive substances (13-24%), vitamins (A, B1, B6, D, E, K) and enzymes (lipoxidase, lipase, urease, amylase). Chen et al. (2010) investigated the nutritional quality of soy flour fermented with *Aspergillus* and *Lactobacillus*, demonstrating a significant improvement in soluble proteins in trichloroacetic acid, in vitro protein digestibility, and available lysine content, especially in the case of fermentation with Lactobacillus. They also produced a large amount of lactic acid, resulting in a lower pH compared to unfermented soy flour or soy protein concentrate ($p<0.05$).

Chickpeas present a several health benefits, being an important source of proteins (18.4 - 29%), lipids (4.5-6%), fibers (4.3-17.4%), carbohydrates (59.5-69.4%) and mineral salts (2.48-3.5%) (Boye et al., 2010). Phenolic compounds from chickpeas, such as Enterodiol, Gomisin D, Anhydro-secoisolariciresinol, Pelargonidin 3,5-O-diglucoside, Hesperetin 3′,7-O-diglucuronide, 6-Geranylnaringenin, Isorhamneti, p-Coumaroyl glucose, hydroxytyrosol 4-O- glucoside, confers antioxidant activity and can prevent degenerative diseases or can be cancer inhibitors (Perez-Perez et al., 2021). Chickpeas are also an important source of polyunsaturated fatty acids (66%) and unsaturated (19% of total fat) (Madurapperumage et al., 2021), which helps to reduce cholesterol, obesity and diabetes (Achari and Jain, 2017).

Obtaining pork meatballs with 30% LM-TVP or HM-TVP from peas, pumpkin or sunflower has been found to result in a slight decrease in protein quality compared to pure meat products, but also an increase in the quantity of mono and polyunsaturated fatty acids, as well as an increase in dietary fiber content (Baune et al., 2022).

More, an increase in dietary fiber content was reported for beef meatballs, in which 10-40% of the beef was replaced with rehydrated LM-TSP, while the total moisture and fat content was lower (Bakhsh et al., 2021).

CONCLUSIONS

According to studies, vegetable derivatives are widely used in the meat industry with positive effects on quality and often with a sensory value close to the meat products or at least accepted by consumers. In addition to nutritional advantages, another important aspect is their accessibility and relatively low price, which allows for sustainable exploitation of resources to ensure food production. The use of raw materials or plant derivatives for the development of new products (meat or other food) is an evolving field that is of interest to scientists and can be further studied.

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