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Reformulated meat product with wild garlic and chestnut flour

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Abstract

In recent years, one of the meat industry's goals has been focused on developing meat products with functional ingredients, in order to improve their nutritional profile and prevent the risk of specific diseases' appearance. The main purpose of this work was the preparation of a reformulated meat product with the addition of wild garlic and chestnut flour, aiming the improvement of its nutritional characteristics, reducing the fat content and extending the shelf life. The classic mixture of ingredients for concerned meat product was used as a control sample, while other four samples were reformulated by the partially addition of wild garlic and chestnut flour in different proportions. Total phenolic compounds of wild garlic and chestnut flour was determined according to the Folin–Ciocalteu method. Water binding capacity and oxidative stability of reformulated samples were evaluated in relation with the control sample.

Keywords: reformulated meat product, wild garlic, chestnut flour

1. Introduction

Meat products - nutritional quality and nutritional deficiencies

Meat and meat products represent an important component of human diet, considered essential for the optimal development of the body and also indispensable from a nutritional point of view, in the context of life in our modern society [1]. Meat and meat products, as part of the human diet, represent an important source of energy and nutrients, including high-quality proteins (with a good balance of amino acids), minerals (iron, zinc, selenium, magnesium) and vitamins (especially vitamin B12, folic acid). Through the nutrients it contains, meat plays a significant part in defending the organism (these increase resistance to infections and different toxic substances), which stimulates a person's work and intellectual capacity, as well as higher nervous activity [2].

In addition to basic nutrients, meat also contains a series of bioactive components with important biological functions, such as:

- carnitine and carnosine, which have the capacity to eliminate free radicals and chelate metals;
- taurine, which has the role of protecting the retina and of reducing the level of free and esterified cholesterol [3];
- peptides with antithrombotic properties and cytotoxic effect against certain cancerous cells [4].

On the other hand, besides the nutritional benefits, specialised studies have revealed the relationship between the high red meat consumption and an increased risk for different types of cancer, especially for the colorectal ones [5]. Consumption of processed meat can also be associated with the risk of developing cardiovascular diseases and various metabolic disorders (diabetes, obesity). The causes that might generate these associations can be the high content of saturated fats, salt and some compounds that are formed while meat is processed, such as nitrosamine, biogenic amines, heterocyclic aromatic amines and polycyclic aromatic hydrocarbons [6, 7].

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Recent trends in meat products' development

In the last years, researchers and food producers have looked to develop alternative meat products with a lower content of additives, fats, cholesterol or sodium chloride and a higher content of nutrients or bioactive compounds with good protective or preventive properties against human diseases [8].

One of the strategies for enhancing meat products' quality consists in the replacement of harmful components and toxic additives with natural compounds from various sources, that are rich in bioactive compounds such as antioxidants, polyphenols, probiotics, prebiotics, vegetable proteins, dietary fibres or vitamins [9-12].

Wild garlic and chestnut flour – potentially functional ingredients for meat products

Wild garlic or bear`s garlic, *Allium ursinum* L., is an aromatic plant widespread in Europe, that provides potential health benefits mainly due to the sulphur containing substances and polyphenols [13]. According to several studies, *Allium ursinum* L. plants or extracts are considered to have some biological properties, due to their antioxidant, antimicrobial, antiseptic, antifungal, cytostatic and antidiabetic activities [14-16]. Wild garlic's abundance in spontaneous flora, its important content in bioactive compounds with high technological and therapeutical potential, together with its specific sensorial characteristics (taste, flavour, odour) make this plant a valorous candidate for several functional meat products.

In recent years, chestnuts (*Castanea sativa* Mill.) and chestnut flour have gained popularity in the human diet due to their nutritional composition. They are an important source of several bioactive compounds that have been associated with the anti-inflammatory effect, prevention of cardiovascular diseases and cancer, proving also a significant role in preventing cellular degeneration [17, 18]. Considerable amounts of dietary fibres can also be noticed (4 – 10 %), with importance in intestinal health and role in lowering of low-density lipoprotein cholesterol [19, 20]. In addition, dietary fibres incorporated into meat products improve their water-binding capacity, rheological properties and cooking yield [21]. Chestnut flour is therefore considered an interesting ingredient for the production of innovative and fortified product formulations.

The objective of this study was to improve the nutritional characteristics of an emulsified meat product, with the aim of evaluating the effects of the addition in its composition of various levels of wild garlic powder and chestnut flour.

2. Materials and Methods

2.1. Materials

Both fresh beef chuck and pork back fat were purchased from a local supermarket, transported under refrigerated conditions (4°C) and immediately processed in the Research Pilot Laboratory of „Aurel Vlaicu" University from Arad.

Wild garlic *Allium ursinum* L. was collected from Buteni area, Arad County, during the spring of 2021. Fresh leaves of the plant were hand selected, washed, dried at 42°C until constant mass and then grinded in a blender. Grinded samples were sifted and stored in glass containers at room temperature, in a dark place, until use.

Chestnut flour was purchased from a local supermarket from Arad, Romania.

Folin–Ciocalteu reagent and gallic acid were purchased from Sigma (Sigma–Aldrich GmbH, Sternheim, Germany). The other chemicals and reagents were an analytical grade. Saturated potassium iodide solution, 7.5% sodium carbonate, and 1% starch solution was freshly prepared.

2.2. Water-binding capacity of chestnut flour

The water-binding capacity (WBC), defined as the amount of water retained by the sample under low-speed centrifugation, was determined as described in the standard method used by the AACC (American Association of Cereal Chemists) [22, 23]. Samples (13 ± 0.005 g) were mixed with distilled water (20 ml) in plastic test tubes, homogenized and centrifuged at 4000 rpm for 10 min at room temperature. WBC was expressed as grams of water retained per gram of solid. Values were the average from three replicates.

2.3. Total phenolic content of wild garlic powder and chestnut flour

Extraction: 2 g of each sample (2 g) were introduced in Erlenmayer flasks and 20 mL of 80% ethanol were added to each. The mixtures were maintained for 8 h at 50°C and followed by magnetic stirring for 1 h, to optimize the extraction. The mixtures were then centrifuged at 4000 rpm for 10 min at room temperature.

The supernatants were filtered and used for the determination of total phenolic content (TPC).

TPC was determined using the Foline-Ciocalteu method as described by Wani et al. [24]. Gallic acid was used as reference standard. Standard solutions were prepared at concentrations of 20, 40, 60, 80 and 100 mg kg^{-1}. Results were expressed as gallic acid equivalents (GAE) per 100 g dry weight (DW). Three replicates were performed for each sample.

In short, 2.5 ml of each extract was added to 2.5 mL freshly diluted (1:2) Folin-Ciocalteu reagent. Then, 2.5 mL of 7.5% sodium carbonate solution and 2.5 mL distilled water were also added. The reaction was kept in the dark for 30 min. The same procedure was applied to standard solutions.

The absorbance of samples and standard solutions was read at a wavelength of 765 nm (Shimadzu, UV-1800, Tokyo, Japan).

Test tube with no investigated sample was used as blank. Linearity of the calibration was very good, R^2 = 0.995.

2.4. Meat product preparation

Meat product was prepared with fresh beef chuck and pork back fat and reformulated with different amounts of added chestnut flour and wild garlic powder. Both beef chuck and pork back fat were initially ground through an 8 mm perforated plate. These tissues were then minced and homogenized with the other ingredients by using an electric meat grinder (Philips HR 1964/90). Wild garlic powder (WGP) and chestnut flour (CF) were added to the composition of emulsified meat product as described in Table 1.

Five different samples were reformulated, as follows (Table 1):

Table 1. Formulations of emulsified meat product

Ingredients [g]	P1 (Control)	P2	P3	P4	P5
Meat	100	100	100	100	100
Fat	30	30	30	30	30
Ice flakes	30	30	30	30	30
Sodium polyphosphate	0.5	0.5	0.5	0.5	0.5
Nitric salt	2.6	2.6	2.6	2.6	2.6
Chestnut flour	-	3	6	9	12
Wild garlic powder	-	1.2	0.6	0.6	0.6

Abbreviations: P1…P5 – Samples 1…5 of emulsified meat product

After emulsification, meat batters were packed into pre-weighed glass containers (Figure 1) and heated at 85°C for 1 h. The samples were then cooled (Figure 2) at room temperature and evaluated in regards of cooking loss and oxidative stability.

2.5. Cooking loss of meat product samples

Cooking loss (CL) was determined by calculating the weight difference before and after cooking, as follows [25]:

CL (%) = [(raw sample weight (g) – cooked sample weight (g))/raw sample weight (g)] ×100

2.6. Peroxide value of meat product samples

Peroxide value (PV) is considered an indicator of oxidative stability and was determined according to the method described by Barbieri et al. [26] and Amoli et al. [27]. Meat samples were packed in low density polyethylene bags and stored at 4°C for 30 days.

The PV was determined in the lipid fraction extracted from 10 g of meat product after a storage period of 0, 15, and 30 days. Extracted lipid fraction was dissolved in 30 mL chloroform–acetic acid mixture (1:2), treated with 1 mL of saturated potassium iodide solution and kept in the dark for 5 min. A total of 30 mL distilled water and 1 mL freshly prepared 1% starch solution was added to the mixture and shaken.

The PV was evaluated by titrating iodine released from the potassium iodide with 0.01 N sodium thiosulphate solution, until the moment of blue colour disappearance. PV was calculated as meq O_2 /kg fat, according to the following formula:

$$PV = [(Va - Vb):M] \times 10$$

where Va is the titration value for the sample, Vb is the titration value for the blank and M is the weight of the sample.

Figure 1. Meat batters before heating

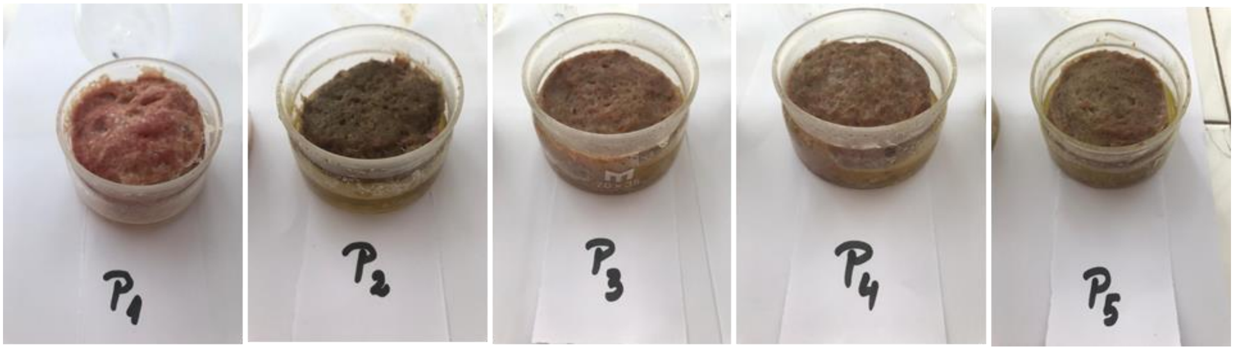

Figure 2. Meat batters after heating

3. Results and Discussion

3.1. Water-binding capacity of chestnut flour

The calculated values of WBC for the three evaluated samples are reported in Table 2. Chestnut flour exhibited high WBC values (1.675 – 1.742 g/g), **due** to its high fibres content, in accordance with the results obtained by Paciulli et al. [28] and Littardi et al. [22].

Table 2. Water-binding capacity of chestnut flour samples

Sample	WBC (g/g)
CF1	1.742 ± 0.020
CF2	1.705 ± 0.039
CF3	1.675 ± 0.026

± SD: Standard deviation of three replicates

3.2. Total phenolic content of wild garlic powder and chestnut flour

Phenolic content is an important parameter for describing antioxidant activity. The results for TPC of wild garlic powder and chestnut flour are presented in Table 3.

The highest amount of polyphenols content was noticed in chestnut flour. The averaged values of TPC ranged from 892.6 mg GAE/100 g DW in CF2 to 974.4 mg GAE/100 g DW in CF3. This may be due to the high levels of gallic and ellagic acids, catechins and flavonols [24]. Total phenolic content in wild garlic powder was 143.11 mg GAE/100 g DW. The obtained values were in accordance with data encountered within some other studies [13, 29].

Table 3. Total phenolic content (TPC) of chestnut flour and wild garlic

Sample	TPC (mg GAE/100 g DW)
CF1	965.9 ± 0.74
CF2	892.6 ± 0.31
CF3	974.4 ± 0.62
WGP	143.3 ± 0.25

± SD: Standard deviation of three replicates

3.3. Cooking loss of meat product samples

The cooking loss of evaluated emulsion-based meat product samples is presented in Table 4. The highest value for CL was encountered at the control sample (18.73%). This fact may be attributed to the high loss of moisture and fat during cooking. Compared to control, the reformulated samples of same meat product showed a decrease in cooking loss, depending on the level of chestnut flour added. The high quantity of dietary fibres from chestnut flour decreased cooking loss due to their high ability of keeping moisture and fat in the matrix.

The results of this study were similar to those of other studies [30, 31], where the cooking loss values of sausages supplemented with dietary fibres were significantly lower than those of control samples with no dietary fibres addition. As a conclusion, adding them in the composition of meat products can reduce or replace the sodium polyphosphate quantity.

Table 4. Cooking loss (CL) of evaluated emulsified meat product samples

Sample	CL (%)
P1 (Control)	18.73 ± 0.67
P2	16.61 ± 0.51
P3	13.27 ± 0.43
P4	11.75 ± 0.65
P5	11.24 ± 0.86

± SD: Standard deviation of three replicates

3.4. Peroxide value of meat product samples

Meat products are susceptible to lipid oxidation during processing and storage period. It is well known that lipid oxidation reduces meat products' quality and influences their sensory properties, because it leads to colour changes and unpleasant flavours formation [32].

Meat samples reformulated with wild garlic powder and chestnut flour proved a reduced peroxide formation compared to the control sample. The development of lipid oxidation estimated by peroxide value is shown in Figure 3. The results indicated an increasing trend in peroxide values for all the samples during storage, but these values did not exceed the acceptable limits for peroxide value in meat products (10 meq O_2 /kg) [33].

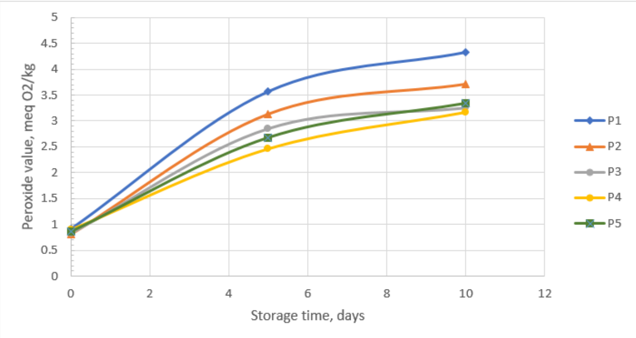

Figure 3. Evolution of peroxide values of evaluated emulsified meat product samples during storage

It can be noticed that the PV of the control sample was significantly higher than the other samples supplemented with wild garlic powder and chestnut flour.

The lowest PV after 10 days of storage was found in P4 (9% CF, 0.6% WGP), 3.17 meq O_2 /kg, comparable with P3 (6% CF, 0.6% WGP), 3.25 meq O_2 /kg, and P5 (12% CF, 0.6% WGP), 3.34 meq O_2 /kg indicating that incorporation of wild garlic powder and chestnut flour can be an effective strategy for improving lipid stability.

4. Conclusions

i. Wild garlic and chestnut flour are vegetable products characterized by a high content of polyphenolic compounds.

ii. Chestnut flour possesses a high WBC so that can partially replace the addition of polyphosphates in meat products.

iii. The use of WGP and CF in emulsified meat systems, in the experimentally optimized ratio (9% CF, 0.6% WGP), led to the obtaining of some products characterized by:

- improved nutritional value due to the addition of dietary fibres and the reducing of fat content;
- a longer storage time, due to the antioxidant activity assigned to polyphenolic compounds, on the one hand and to the antimicrobial activity of some wild garlic-contained components, on the other hand.

iv. In terms of their properties, CF and WGB can be successfully used in the reformulation of meat products for obtaining new assortments.

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Compliance with Ethics Requirements. Authors declare that they respect the journal's ethics requirements. Authors declare that they have no conflict of interest and all procedures involving human or animal subjects (if exist) respect the specific regulation and standards.

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