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EVALUATION OF SOME NUTRITIONAL COMPOUNDS OF GARLIC *(ALLIUM SATIVUM* L.) PEEL WASTE

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Abstract

Garlic (Allium sativum L.) is known as a valuable spice and common medicine for various diseases. The bulb of garlic is a rich source of nutritional compounds (carbohydrates, proteins, minerals, fibre), vitamin and other biologically active natural compounds, with beneficial effects on the body's health. The skins obtained when peeling the garlic bulb also contain important amounts of proteins, fibres, minerals, carbohydrates and essential phytochemicals. The purpose of this work is to evaluate the content of nutritional compounds from the peel of garlic bulbs sold in local agri-food markets. The obtained results show that the analysed garlic peel contains important amounts of nutritional compounds whose value varies depending on the origin of the garlic: 4.21-5.36% moisture, 15.18-16.53% minerals, 7.38-8.11 protein, 58.77-63.46% fibres, 20.56-21.64%, 0.52-0.78% fat. The preliminary results suggest that the investigated garlic peel could be considered for obtaining products with additional content of nutritional compounds. Also, the superior valorization of garlic peels can be an ecological method of garlic peel waste resulting from peeling garlic bulbs.

Key words*: garlic, garlic peel, by-products, nutritional parameters.*

INTRODUCTION

Garlic (*Allium sativum* L.), belonging to the *Amaryllidaceae* family, is one of the most widespread aromatic food plants (Lasalvia et al., 2022). It is used to obtain traditional products such as stews, mayonnaise, sausages, ketchups and salads, but it can also be used for health purposes to reduce blood pressure, cholesterol and triglyceride levels in the blood, to control the aggregation of platelets; to inhibit cancer cells or as an antimicrobial agent (Prakash and Prasad, 2023; Essa et al., 2023).
Consumption of garlic and its supplements reduces the risk of diabetes and cardiovascular disease and strengthens the immune system with antibacterial, antifungal, anti-aging and anti-cancer properties (Sunanta et al., 2023; Verma et al., 2023); it was used as a spice, but also a remedy during various epidemics (dysentery, typhoid fever, cholera, flu) and other diseases (Yusuf et al., 2018). Due to its biologically active component, allicin and its derivatives, garlic has long been used as a medicine to prevent and treat a variety of diseases and disorders, including high blood pressure, high cholesterol, coronary heart disease, and cancers such as the colon, rectal, stomach, breast, prostate and bladder cancers, as well as lung cancer and cardiovascular diseases such as antilipemic, hypotensive, enlarged prostate, diabetes, osteoarthritis, allergic rhinitis), traveler's diarrhea, preeclampsia, in the treatment of some epidemics (dysentery, typhoid fever, cholera, influenza) (Azmat et al., 2023; Verma et al., 2023; Sunanta et al., 2023; Prakash & Prasad, 2023; Prakash, et al., 2023; Essa et al., 2023; Lyngdoh and Ray, 2022; Tosin et al., 2017; Saif et al., 2020; Martins et al., 2016; Tesfaye, 2021). Analyzing seven varieties of garlic, Prakash and Prasad observed that they contained variable amounts of moisture (64.16-74.57%), crude protein (4.23-7.39%), crude fat (0.18-0.91%), ash (0.92-1.7 1%), carbohydrate (18.94-29.18%), crude fiber (0.58-0.84%), total soluble solids (28.93-37.93^{0}Brix), acidity (0.73-1.24%), and pH = 6.08-6.77 (Prakash and

Prasad, 2023). The pungency factor as pyruvic acid was found to be in the range of 34.84 - 86.69 μmol/mL, whereas anti-nutritional factors such as saponin (6.63-13.98 g), phytic acid (0.03-0.6 g), and tannin (0.18-0.39 g CE) per 100 g on a fresh weight basis were present (Prakash & Prasad, 2023).

The chemical composition and content of bioactive compounds in garlic products varies with genotype, cultivation practices, growing conditions, plant density, soil type, fertilizer application rate, and processing method of these products (Chen et al., 2019).

Garlic peel is one of the crucial unit operations for the use of garlic at an industrial scale. It has been reported that this by-product contains significant amounts of nutritional compounds and phytochemicals (dos Santos et al., 2022; Azmat, et al., 2023). The quantities and qualities of the compounds included in the composition of garlic peel give this by-product numerous biological properties, such as: antioxidant, anticancer, antidiabetic, antimicrobial, antiviral, anti-inflammatory, cardioprotective, neuroprotective, hepatoprotective which have allowed its use to treat and to prevent various diseases due to its medicinal properties (Azmat et al., 2023). Garlic peels is rich in cellulose content (Prakash et al., 2023). In addition, it contains important quantities of functional ingredients and can be used as a functional material for the production of high-added value products (Kallel et al., 2017; Kim et al., 2010). Garlic peel is also known to have excellent physiological activity and is consumed at home in the form of broth, tea, etc. (Kim et al., 2010).

According to Kallel et al., the skin resulting from the peeling of garlic bulbs, initially considered as garlic waste, is an inedible by-product of garlic that has a moisture content of 3.52%, a high protein content of 8.43%, a low content of lipids of 0.86% and a high total fibre content of 62.23% (Kallel et al., 2017). Zhivkova, was found that garlic wasted peels were characterized by the highest content of total dietary fibre (62.10%), total sugars (6.51%), dry matter (80.8%), total ash (7.37%), (Zhivkova, 2021). In addition, the garlic peel also contains 8.5% digestible carbohydrates, 1.36% reducing sugars, 2.61% crude protein and 0.22% free fat (Zhivkova, 2017).

Analyzing quality characteristics of garlic peel, Min et al., have identified the following contents of chemical compounds: 10.97 g/100 g moisture, 3.39 g/100 g crude protein, 0.56±g/100 g crude fat, 5.83/100 g crude ash, 79.25 g/100 g carbohydrate, 6.25% total pyruvate, 57.77 mg/100 g total polyphenol, 3.68mg/100g total flavonoid, 57.45% DPPH radical scavenging ability (Min et al., 2020). Experimental studies of Lyngdoh and Ray showed that garlic peel was a very rich source of ash, crude fibre and protein content: 16.34% ash, 21.71% carbohydrate, 60.57 crude fibre, 0.83% fat, 3.36% moisture content and 8.24% protein (Lyngdoh and Ray, 2022). Data regarding moisture and mineral content (ash) from garlic peel, were also reported by Pathak et al.: 5.84% moisture and 8.47% ash content (Pathak et al., 2016). Also, in raw garlic peel powder, notable amounts of dry matter (13.35%), protein (1.30%), fat (1.14%) fat, ash (5.41%), pectin (16.71%), lignin (8.26%), cellulose (31.36%), hemicellulose (22.47%) and holocellulose (53.83%) (Prakash et al., 2023). Lyngdoh and Ray showed that garlic peel can be a very rich source of ash crude fibre, protein and antioxidants content and can also be used to fortify some food products in order to formulate functional foods (Lyngdoh and Ray, 2022). Furthermore, garlic peel it is a valuable source of phytochemicals and medicinal substances (Azmat et al., 2023), which have various beneficial effects including antioxidant activities, antithrombosis activities and cancer inhibition (Min et al. 2020).

Due to the high protein content garlic peels are use as animal feed additives (Chen et al., 2019). Garlic peels have a high content of polyphenols and fibers and have antibacterial activity similar to garlic, so they can be fed to animals and in some cases, they can be used as an alternative to antibiotics (Kim et al., 2010). Recently, the garlic by-products as alternatives to antibiotics, have been used to manipulate the rumen ecology to achieve better growth performance, reduce methane emissions, and improve the quality of ruminant products and the control of parasite infections (Ding et al.,2023). According to reports garlic peel extracts exhibit significant antioxidant activity and can be used as natural antioxidant in nutraceutical preparations to prevent human

diseases. (Mounithaa et al., 2023; Kim et al., 2016). Garlic peel extract contains phenolic compounds, as does the bulb (dos Santos et al., 2022). Garlic peel extracts have been reported to possess antifungal effects and antiviral properties, such that they could be used in the management of drug-resistant microbial diseases (Azmat et al., 2023). Based on the evidence provided by the above studies, there could be the possibility of using garlic peel extract as a natural food additive or even as a functional food. The evidence provided by studies on the nutritional composition of garlic peels shows that this product resulting from peeling garlic bulbs contains important amounts of nutritional compounds, especially carbohydrates, fibres, minerals and proteins. Therefore, the problem arises of using this by-product as a potential alternative food source in the creation of dietary supplements or functional meals. The purpose of this paper is to evaluate the content of nutritional compounds in the peel of garlic bulbs sold by domestic producers on the agri-food markets in Timișoara (Romania) in view of the possibility of using them as additional nutritional sources in obtaining products with added food value.

MATERIALS AND METHODS

Plant material consisted of garlic peels (GPs) obtained by peeling the bulbs of white garlic (*Allium sativum*) taken from three domestic producers from different agro-food markets in Timisoara (Figure 1).

Figure 1. The bulbs and cloves of white garlic

In the context of the present study, the outer and inner peels resulting from the peeling of bulbs and cloves were considered as garlic peel waste. Three batches of average samples of garlic bulbs marked P1, P2 and P3 were formed, corresponding to the three providers from which they were collected. Peeling was done manually, and the obtained peels were washed in running tap water first, then in distilled water, to remove adhering debris and dried in an oven at 60^0C for 10 hours (Figure 2).

Figure 2. The peels of white garlic

The dried garlic peels, three samples for each batch were then ground using a kitchen grinder (Figure 3) and used to determine the concentrations of the nutritional parameters of interest: moisture, minerals (ash), protein, fat, fibre, and carbohydrate. Until the time of analysis, the garlic peel powder samples were kept in polyethylene ampoules in the refrigerator, at 4^0C.

Figure 3. Peels and powder of white garlic

The determination of the nutritional composition of the powder of GPs studied was performed according to AOAC Official Methods of Analysis, 2000 (AOAC, 2000) and according to the recommendations of Velciov et al. and Satti et al. (Velciov et al., 2022; Satti, et al., 2018). For moisture content, dried garlic peel powder was dried in an oven at 105 ^{0}C to constant mass (Velciov et al., 2022). The ash content was determined by the calcination method at 550°C (Velciov et al., 2022). The protein content was determined by the Kjeldahl

method, using a conversion factor for nitrogen of 6.25. (Velciov et al., 2022; Satti, et al., 2018). The crude fat was determined using the Soxhlet method with hexane as solvent (Velciov et al., 2022; Satti et al., 2018). Crude fibers were determined by using the method of acid - base digestion (Satti et al., 2018). The carbohydrate content was obtained by difference (Velciov et al., 2022). All the data was statistically analyzed for variance (ANOVA) using Statistica 10. The comparisons for means were done using Duncan's Multiple Range Tests (DMRT). Duncan's Multiple Range Tests or Duncan's New Multiple Range Tests provide significance levels for the difference between any pair of means, regardless of whether a significant F resulted from an initial analysis of variance. The Shapiro-Wilk test was used to assess the normality of the data (Ghosh & Mitra, 2020).

RESULTS AND DISCUSSIONS

The experimental results obtained for the determination of moisture, minerals (ash), protein, fibres and carbohydrates from GPs are presented in table 1.

The results obtained, based on the official methods of analysis, show that the analysed GPs contains significant amounts of nutritional compounds whose value varies depending on the origin of the garlic: 4.21-5.36% moisture, 15.18-16.53% ash (minerals), 7.38-8.11 protein, 0.52-0.78% fats, 58.77-63.46% fibres, 20.56-21.64%.

The moisture content of the product provides information on the amount of water contained in a certain product, respectively the amount of dry substance of the respective product. Furthermore, the moisture is important for food preservation and in food processing therefore (Velciov et al., 2022).

It has been established from various researches that foods with low moisture content (especially those with less than 10%) have a longer shelf life with limited deterioration of quality due to microbial activities; those with a moisture content of more than 10% cannot be stored for a long time (Tosin et al., 2017).

As can be seen from Table 1 and Figure 4 the GPs present low amounts of moisture, between 4.21% (GP1)-5.34% (GP2). The highest value has been determined in GP2 (5.36±0.34%): lower values were identified in GP3 and GP1 (4.78±0.33, respectively (4.21±0.23%). In this order, the dry matter content increases. Having a water content of less than 10%, the GPs obtained and analyzed can be kept for a longer period of time.

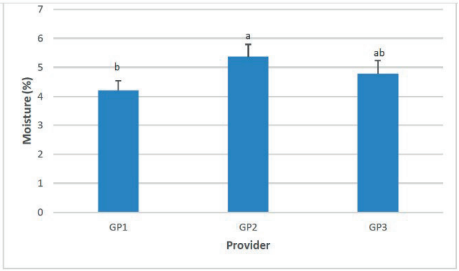

Figure 4. The moisture content in garlic peel

The assumption of normality moisture content distributions was assessed by using the Shapiro-Wilks test. Results indicated that the moisture contents are normally distributed (for GP1: W= 0.987, p=0.78; for GP2: W=0.987, p=0.78; for GP3: W=1, p=1). A one-way ANOVA was performed to compare the effect of the three different providers on moisture contents. It revealed that there was a statistically significant difference in mean moisture contents between at least two groups ($F = 6.001$, $p = 0.037$). Duncan's MRT for multiple comparisons found that the mean value of moisture content was significantly different between provider 1 and provider 2 ($p = 0.0156$, 95% C.I. = [0.30, 2.00]). There was no statistically significant difference in mean moisture contents between provider 1 and provider 3 (p=0.136) or between provider 2 and provider 3 (p=0.131). GPs humidity values determined in this experiment are comparable to those determined by Pathak et al., and Ifesan et al.: 5.84, respectively 5.50% (Pathak et al., 2016; Ifesan et al., 2014). Higher values have been reported by Hagag et al., Ding et al., Min et al., Prakash et al., and Zirkova et al.: 9.44, 8.2-9.4, 10.97, 13.35, respectively 19.2% (Hagag et al., 2023; Ding et al., 2023; Min et al., 2020, Prakash et al., 2023; Zirkova et al., 2021); Kallel et al., and Lyngdoh et al. they determined small values: 3.52, respectively 3.36% (Kallel et al., 2017; Lyngdoh et al., 2011).

Table 1. The nutritional parameters of garlic peel (mean values, reported to dry matter)

Specification	Nutritional values (%)*					
	Moisture	Ash	Protein	Fats	Fibres	Carbohydrates
Provider 1 (GP1)	4.21±0.23b	16.53±0.63a	7.38±0.20a	0.52±0.07b	58.77±1.61b	21.64±0.82a
Provider 2 (GP2)	5.36±0.34a	15.18±0.74a	8.11±0.39a	0.78±0.10a	63.46±1.83a	20.56±0.98a
Provider 3 (GP3)	4.78±0.33ab	16.22±0.71a	7.63±0.37a	0.60±0.04ab	61.86±1.31ab	21.24±0.92a

Ash content indicates the amount of inorganic matter and oxides present in the sample, respectively the sum of the mineral elements that are part of the analysed samples (Velciov et al., 2022). Minerals are indispensable components of our dietary intake, performing a diverse array of functions: serve as the fundamental elements for our skeletal structure, influence muscle and nerve activity and regulate the body's hydration balance, are integral parts of hormones, enzymes, and other biologically - active substances and some play a critical role in optimizing the functionality of the immune system (Stefanache et al., 2023). A high ash content is an indication of high inorganic mineral content (Tosin, 2017). According to Zhivkova et al., 2021 garlic peel contains important amounts of essential macro and microelements (mg/kg), as: Ca (20610), Ca, K (9081), S (635), Mg (950), Al (826), P (721), Fe (682), Na (123), Mn (35.4), Cr (18.40), B (18.0), Zn (12.9), Cu (2.09), Se (0.058) (Zhivkova et al., 2021).

The results obtained when determining the ash content (table 1 and figure 5) show that samples of GPs contain increased amounts of minerals between: 15.18-16.53%, depending on their provider.

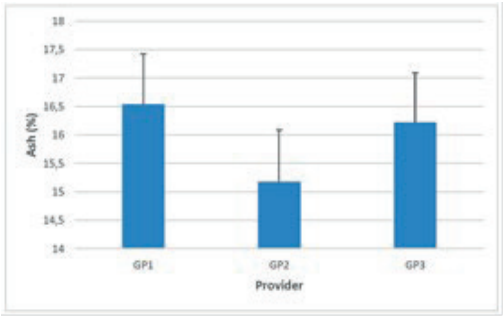

Figure 5. Ash (minerals) content in garlic peel

The richest in minerals are GPs from garlic bulbs P1 and P3, which contain amounts relatively close to ash: 16.53±0.63, respectively 16.53±0.63%. Slightly smaller amounts were determined in GP1 (15.18±0.74%).

The assumption of normality ash content distributions was assessed by using the Shapiro-Wilks test. Results indicated that the ash contents are normally distributed (for GP1: W= 1, p=0.98; for GP2: W=0.996, p=0.87; for GP3: W=0.99, p=0.91).

A one-way ANOVA was performed to compare the effect of the three different providers on ash contents. It revealed that there was not a statistically

significant difference in mean ash contents between the groups (F = 1.938, p = 0.224). Experimental data (table 1) shows that the GPs analyzed contain high amounts of minerals and therefore they could be considered as mineralizing products. Therefore, GPs obtained from the peeling of garlic bulbs, after a preliminary processing (cleaning, drying, grinding, possibly extraction in hydroalcoholic solvents) could be used as a mineral additive to obtain food with the added value or in animal feed. This statement is supported by other studies (Lyngdoh et al., 2022; Ding et al., 2023).

Proteins are essential component of the diet needed for the survival of animals and human, they serve as source of nitrogen in the body system along with the amino acids; good skin, increase in growth and ability to replace the worn-out cells are the quality of protein in the body (Tosin et al., 2017). Protein deficiency is closely related to a number of diseases such as Kwashiorkor, Marasmus (energy deficiency), mental disorders, insufficiency of different organs, edema and immune system weakness and increased protein intake plays an important role in diets intended especially for athletes or diseases related to diabetes and the cardiovascular system (Velciov et al., 2022). There are 67 proteins in both the inner and outer garlic protein in peel (Azmat et al., 2023). The GPs analyzed in this experiment contain significant amounts of protein, the protein

content values being within relatively close limits: 7.38-8.11% (table 1 and figure 6). However, it can be observed that GP2 has a slightly increased content (8.11±0.39%), compared to GP1 and GP3 (7.38±0.20%, respectively 7.63±0.37%).

The assumption of normality protein content distributions was assessed by using the Shapiro-Wilks test. Results indicated that the protein contents are normally distributed (for GP1: W= 0.992, p=0.83; for GP2: W=0.857, p=0.25; for GP3: W=0.983, p=0.74).

A one-way ANOVA was performed to compare the effect of the three different providers on protein contents. It revealed that there was not a statistically significant difference in mean protein contents between the groups (F = 2.375, p = 0.174).

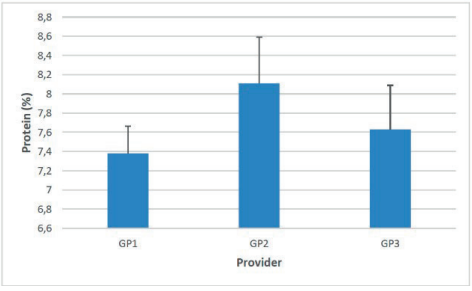

Figure 6. Protein content in garlic peel

These values are consistent with those obtained by Lyngdoh & Ray and Kallel et al.: 8.24, respectively 8.40% (Lyngdoh & Ray, 2022; Kallel et al., 2014); much higher values have been reported by Ding et al. and Hagag et al.: 13.10-13.65%, respectively 18.6% (Ding et al., 2923; Hagag, et al., 2023). Lower and very low concentrations have been reported by Prakash et al., Zhivkova, 2021, Min et al., Kim et al.: 1.3, 2.61, 3.39 and 2.61% (Prakash et al., 2023; Zhivkova, 2021; Min et al., 2020; Kim et al., 2010), respectively Nagorao and Ifesan et al.: 0.4 and 0.57% (Nagorao, 2014; Ifesan et al., 2014).

Fats are essential macronutrients that play an important physiological and biochemical role in the function of the human body, such as energy storage, structural components of biological membranes, electron carriers, enzyme cofactors light-absorbing pigments, hydrophobic anchors for proteins and emulsifying agents in the digestive tract (Baeza-Jiménez et al., 2017). Furthermore, lipids are also used as food ingredients, thus improving texture, taste and flavour of new formulations (Velciov et al., 2022). The analyzed GPs contain low amounts of total fats (Table 1 and Figure 7) the concentrations presenting close values included in concentration limits between: 0.52-0.78%.

The assumption of normality fat content distributions was assessed by using the Shapiro-Wilks test. Results indicated that the fat contents are normally distributed (for GP1: W= 0.993, p=0.84; for GP2: W=0.959, p=0.60; for GP3: W=0.997, p=0.90).

A one-way ANOVA was performed to compare the effect of the three different providers on fat contents. It revealed that there was not a statistically significant difference in mean fat contents between the groups (F = 5.107, p = 0.0507).

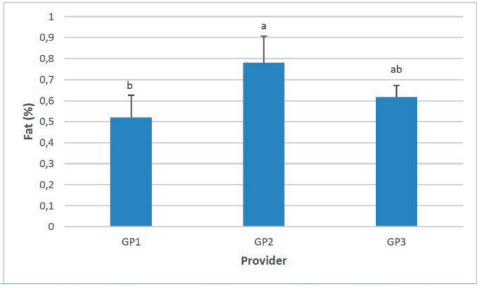

Figure 7. Fat content in garlic peel

These values are comparable to the values determined by Lyngdoh et al., Min et al. and Kallel et al.: 0.83, 0.56, and 0.86% (Lyngdoh et al., 2022; Min et al., 2020; Kallel et al., 2017). Higher values were determined by Prakash et al., and Kim et al.: 1.30%, respectively 1.26% (Prakash et al., 2023; Kim et al., 2010). Much lower and very low values of the fat content were reported by Zhivkova and Ifesan et al.: 0.22 and 0.05% (Zhivkova, 2022; Ifesan et al., 2014). Therefore, the GPs analyzed contain low amounts of lipids, a fact also recorded by Azmat et al., who reported that GPs have a high protein content and a low lipid content (Azmat et al., 2023). According to Lyngdoh et al., the incorporation of garlic peels exhibited increasing protein content but decreasing fat content in the valued-added product (Lyngdoh et al., 2022).

The term crude fibre refers to the insoluble dietary fibre fractions and comprises the constituents of the cell walls found in plant tissues, including lignin, cellulose and hemicellulose (Urban et al., 2023). Cellulose, hemicellulose and lignin are well known for water absorption and regulation of the intestinal tract, while pectin and gums are important in cholesterol reduction and glucose regulation (Velciov et al., 2022). Crude fibre helps maintain the normal peristaltic movement of the intestinal tract, therefore, aids in the digestion of food and can be widely used in the food industry when they are incorporated into many foods in order to enrich their nutritional and sensory properties (Velciov et al., 2022). The increased content in raw fibres is due to the increased content of cellulose and lignin from garlic peel. The components of crude fibre are as follows: 50-80% of the total cellulose, 10-15% lignin and only 20% hemicellulose (Urban et al., 2023). The values obtained when determining the fibre content of the investigated GPs batches show close values between 58.77-63.46% (Table 1 and Figure 8). However, comparing the fibre content values between the three batches of GP, it can be seen that batch GP2 is slightly richer in fibers (63.46±1.83), compared to batches GP1 and GP3 (58.77±1.61, respectively 61.86±1.31%).

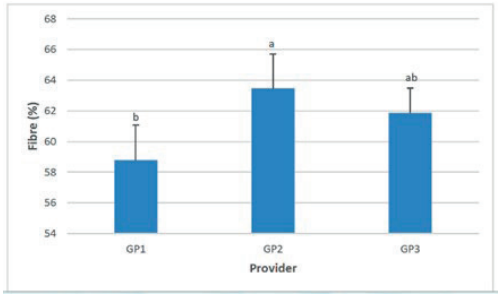

Figure 8. Fibre content in garlic peel

These values show that the garlic peel resulting as waste from the processing of garlic bulbs contains increased amounts of fibre. This statement is confirmed by some previous studies that showed that garlic peel, obtained as a by-product during the processing of garlic, after a preliminary processing, can be used as an additive in obtaining products with added value (Azmat et al., 2023; Lyngdoh and Ray, 2022).

The assumption of normality fibre content distributions was assessed by using the Shapiro-Wilks test. Results indicated that the fibre contents are normally distributed (for GP1: W= 1, p=0.96; for GP2: W=1, p=0.97; for GP3: W=0.999, p=0.95).

A one-way ANOVA was performed to compare the effect of the three different providers on fibre contents. It revealed that there was not a statistically significant difference in mean fibre contents between the groups ($F = 3.96$, $p = 0.0801$).

The values obtained when determining the fibre content of the analyzed GPs are close to those obtained by Lyngdoh and Ray., Zhivkova, Lyngdoh et al., and Ifesan et al.: 60.57, 62.1 and 63.23 - when analyzing similar products (Lyngdoh et al., 2022; Zhivkova, 2021; Kallel et al., 2014).

Carbohydrates are one of the three macronutrients in the human diet, along with protein and fat. They play an important role in the human body: act as an energy source, help control blood glucose and insulin metabolism, participate in cholesterol and triglyceride metabolism, and help with fermentation (Holesh et al., 2023). Although there are different types of carbohydrates, only total carbohydrates are taken into consideration in food and remains when the protein, fat, moisture and ash of the food have been removed (Velciov et al., 2022). The weight of the garlic peel is roughly 26.58% total carbs and 18.62% cellulose; it contains a variety of sugars, including rhamnose, trehalose, mannitol, and sorbitol (Azmat et al., 2023). As shown by the Table 1 and Figure 9, the GPs analyzed contain important amounts of carbohydrates, between close concentration limits: 20.56-21.64%. Slightly higher values, but very close, were determined in GP1 and GP3 (21.64±0.82, respectively 21.24±0.92%; compared to these, the GP2 samples contain slightly reduced amounts of carbohydrates (20.56±0.98%).

These values show that the GPs sample analyzed are rich in carbohydrates, a fact also recorded by Prakash et al., Min et al., and Ifesan et al., which, when analyzing similar products, determined the following values:

78.80, 79.78, and 93.26% (Prakash et al., 2023; Min et al., 2020; Ifesan et al., 2014).

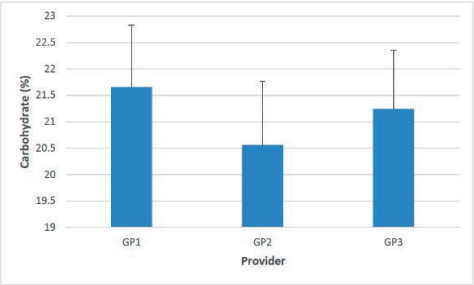

Figure 9. Carbohydrate content in garlic peel

The assumption of normality carbohydrate content distributions was assessed by using the Shapiro-Wilks test. Results indicated that the carbohydrate contents are normally distributed (for GP1: W= 0.999, p=0.93; for GP2: W=0.825, p=0.17; for GP3: W=1, p=0.98)

A one-way ANOVA was performed to compare the effect of the three different providers on carbohydrate contents. It revealed that there was not a statistically significant difference in mean carbohydrate contents between the groups (F = 0.676, p = 0.544).

Comparing the values obtained in this study with the values reported by different authors, it can be seen that they are comparable to those obtained by Lyngdoh et al. și Nagorao: 21.71, respectively 26.58% (Lyngdoh et al., 2022; Nagorao, 2014), but smaller than those determined by Prakash et al., Min et al., and Ifesan et al.: 78.80, 79.78, and 93.26% (Prakash et al., 2023; Min et al., 2020; Ifesan et al., 2014). Therefore, the analyzed sample GPs, due to the content and beneficial activity of carbohydrates, could be used, as such or their extractions, to obtain food products with added value.

It can be concluded that the garlic peel resulting from the peeling of native garlic bulbs, analyzed in this experiment, contains important amounts of nutritional compounds, which play an important role in the human body. Powder of garlic peels analyzed contain increased amounts of minerals, fibers and significant amounts of proteins and carbohydrates. They also contain small amounts of water and fat. These qualities, to which is added the increased content of bioactive compounds determined in previous studies, recommend their use as additives to obtain food with added value. The hydro-alcoholic extracts of garlic peel powders could be used in the future to obtain functional foods. Finally, it can be stated that the garlic peels, this precious by-product, after a prior processing, can be used in the development of new products with high added value in the food and fodder industry due to their improved nutritional profiles. In addition, the recovery of garlic peels as a material for obtaining products with added food value could be an ecological way of reducing the waste resulting from the processing of garlic.

CONCLUSIONS

It can be concluded that the garlic peel resulting from the peeling of native garlic bulbs, analyzed in this experiment, contains important amounts of nutritional compounds, which play an important role in the human body. Powder of garlic peels analyzed contain increased amounts of minerals, fibers and significant amounts of proteins and carbohydrates. They also contain small amounts of water and fat. These qualities, to which is added the increased content of bioactive compounds determined in previous studies, recommend their use as additives to obtain food with added value. The hydro-alcoholic extracts of garlic peel powders could be used in the future to obtain functional foods. Finally, it can be stated that the garlic peels, this precious by-product, after a prior processing, can be used in the development of new products with high added value in the food and fodder industry due to their improved nutritional profiles. In addition, the recovery of garlic peels as a material for obtaining products with added food value could be an ecological way of reducing the waste resulting from the processing of garlic.

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