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THE IMPACT OF USING OLEOGEL AND BUCKWHEAT FLOUR ON THE PROPERTIES OF SEMI-SMOKED SAUSAGES

Roxana Georgiana BOBEICĂ[1], Andra Sabina VĂLEANU (NECULAI)[2], Gabriel Vasile HOHA[1], Emilian Cătălin NISTOR[1], Benone PĂSĂRIN[1]

[1]"Ion Ionescu de la Brad" Iași University of Life Sciences, Faculty of Food and Animal Sciences, 8 Mihail Sadoveanu Alley, 700490, Iasi, Romania
[2]Research and Development Station for Cattle Breeding Dancu, 9 Iasi-Ungheni Road, 707252, Iasi, Romania

Corresponding author email: pbeno@uaiasi.ro

Abstract

Semi-smoked sausages are a valued food product in Romania, but their high fat content raises significant public health concerns. This study proposes an innovative solution by replacing pork fat with oleogel and adding buckwheat flour, aiming to improve the physicochemical, organoleptic, technological, and functional properties of the product, thus offering a healthier and nutritionally balanced alternative.Oleogel, used as a substitute for animal fat, represents a modern alternative with the potential to reduce the saturated fat content in meat products. Through its structure, oleogel ensures a texture similar to traditional fat, contributing to the maintenance of desired organoleptic properties, such as juiciness and aroma. Additionally, the use of buckwheat flour adds functional benefits due to its rich content of fiber, proteins, and bioactive compounds with antioxidant properties. This combination promises an improvement not only in nutritional value but also in the stability and safety of the product. The study analyzes the impact of these changes on the main characteristics of semi-smoked sausages, such as texture, color, aroma, and technological behavior during processing and storage. The obtained results could contribute to the development of healthier meat products, tailored to current consumer demands, without compromising their quality or acceptability. This approach opens new perspectives in the food industry, promoting innovation and sustainability in food production.

***Key words**: buckwheat flour, nutritional value, oleo gel, organoleptic properties, semi-smoked sausages.*

INTRODUCTION

It is essential or the global population to have access to food proteins that are both sustainable and healthy, such as those from plant-based raw materials (Sharma et al., 2016). For this reason, plant protein sources could represent a viable solution to feed a growing population, provided they meet amino acid requirements and are organoleptically acceptable (Neacsu et al., 2022). Ensuring access to food is an important global issue at all stages of human society development (Ghendov-Moșanu, 2021).
According to specialists from the World Health Organization, human well-being is influenced 50% by each person's lifestyle, 20% by environmental conditions, another 20% by hereditary factors, and only 10% by medical services, which underscores the importance of individual choices, especially regarding nutrition (Popkin et al., 2012).
Currently, food products are created using advanced technologies that allow them to have a long shelf life and attractive sensory characteristics (Inetianbor et al., 2015).
The modification of food composition by adding considerable amounts of plant proteins can significantly influence the specific biochemical balance of a consumer's body (Juvan et al., 2005).
In this context, there is an increased need to develop functional food products (Lisitsyn et al., 2018). If a classification is pursued based on the type of food (cereals, meat products, pastries, etc.), the diseases they can prevent, or improve (such as cancer or diabetes), the physiological effects (for example, antitumor activity, digestion, immunity), and the type of biologically active compounds (antioxidants, vitamins, lipids, etc.), we can achieve a dietary balance among the population (Wieslander, 2020; Ianiţchi et al., 2024).

The use of plant-based raw materials in the production process of meat products represents a necessary and current trend (Prosekov, 2014). These raw materials are used to create functional products. In this category of products, dietary, therapeutic, and preventive options are included, intended for both children and the elderly (Satija et al., 2016).
Combining meat ingredients with plant-based ones contributes to increasing the nutritional and biological value of meat products, thus reducing losses during thermal processing (Prosekov et al., 2020). The introduction of plant raw materials into meat product recipes helps improve their physical, chemical, functional, technological, and organoleptic characteristics (Bronnikova et al., 2018).
In Romania, sausages are highly appreciated, being predominantly included in traditional diets. However, a concerning aspect for consumer health is the high content of saturated fatty acids. The long-term impact on health manifests through the increased incidence of cardiovascular diseases, chronic conditions, and obesity (Tilman et al., 2014). The purpose of this paper is to present the importance of protein additives in meat products, as the interest in a balanced and healthy diet has increased among the population.
Replacing pork fat with oleo gel and adding buckwheat flour, with the aim of improving the physicochemical, organoleptic, technological, and functional properties of the product, offers a healthier and nutritionally balanced alternative (Dinu et al., 2017).

MATERIALS AND METHODS

For the completion of this work, academic articles, specialized books, and official reports published between 1990 and 2024 were consulted. These resources were available on websites managed by renowned institutions as well as on search engines such as Google Scholar, PubMed, and Scopus.
The keywords used in the search included: "semi-smoked sausages", "oleo gel", "buckwheat flour", "organoleptic properties", and "nutritional value".
The selection of works was based on their relevance to the proposed topic, considering both experimental studies and synthesis articles. Materials that analysed both the chemical compounds of protein additives (buckwheat and oleo gel) and the importance of their use in meat products were included. The extracted information was then grouped and synthesized into the text, with the aim of providing a clear and accessible overview of the main conclusions from the specialized literature.

RESULTS AND DISCUSSIONS

Buckwheat: chemical composition

Buckwheat is a member of the Polygonaceous family, specifically the genus Fagopyrum (Sangma et al., 2010). Cymosum and urophyllum are its two monophyletic groups (Luthar et al., 2021).
A gluten-free crop, buckwheat has a lot of potential as a cereal alternative. The concentrations of mineral elements in two species of buckwheat, such as Tartary buckwheat (*Fagopyrum tataricum* Gaertn) and common buckwheat (*Fagopyrum esculentum* Moench), are found to be impacted by the way grains are processed into groats (using hydrothermal processing to remove the husk) and sprouts (7-day seedlings) (Zhao et al., 2023).
However, despite being a less common plant in agriculture, sarraceno trigo (*Fagopyrum esculentum* L.) has long been known for its health benefits. The alforfon semillas are dark-marred and triangular, measuring roughly 4-6 mm in length, 2.7-3.5 mm in width, and 2.5-3.3 mm in width. It is used in the form of flour for a variety of products (Zhang et al., 2021). The fact that buckwheat is a gluten-free grain is a significant feature that makes it appropriate for those who are gluten intolerant. With an absorption rate of up to 80-85%, buckwheat grains have the greatest protein content of any cereal (Bonafaccia et al., 2003). The chemical composition of buckwheat grains is presented in the Table 1. These proteins consist of globulins, glutelin, and important amino acids like cysteine, tryptophan, lysine, and threonine; buckwheat has 18 amino acids in total (Bonafaccia et al., 2003; Huda et al., 2021). Furthermore, rutin, a glucosidal flavonoid, helps preserve the flexibility of blood vessels, and buckwheat grains are high in antioxidants. About 25% of the carbohydrates in buckwheat are made up of starch (Woo et al., 2016).

Buckwheat grains are classified as pseudocereals with high nutritional value due to their protein content (Zhu, 2021).

Table 1. The chemical composition of buckwheat grains (Ghendov-Moșanu, 2021)

Indicators	Buckwheat
Water, %	11-12
Glucide, %	67-73
Lipid, %	2.3-3.6
Protide, %	12-18
Cellulose, %	7.3-10.9
Minerals, %	1.8-2.1

Although buckwheat has a relatively low protein content (common buckwheat: 10.6 g/100 g dry weight; tartary buckwheat: 10.3 g/100 g dry weight), it stands out due to its balanced amino acid composition, with significant levels of essential amino acids such as leucine and lysine (common buckwheat: 10.3 g/100 g protein; tartary buckwheat: 7.11 g and 6.18 g/100 g protein) (Bobkov, 2016).
Additionally, the high content of proteins, flavonoids, and trace elements in certain fractions of buckwheat suggests that they can be used in food products intended for special diets (Zhu, 2016). The nutritional value of buckwheat can be observed in Figure 1 and the chemical structures of the isolated components in Figure 2.

Figure 1. The nutritional value of buckwheat grains (S.R.L. Vitalcomus)

Buckwheat proteins can also contain selenium, an essential trace element for human nutrition (Skrabanja et al., 2004).

Oleogels: application

Regulations are becoming increasingly strict regarding the use of trans and saturated fatty acids (Igenbayev et al., 2022). Moreover, consumers are increasingly concerned about the negative effects of certain fats on health, leading to significant changes in the food industry (Badar, 2021).
Moreover, the environmental impact and health issues associated with the extensive use of palm oil, both in the food sector and in biodiesel production, have stimulated the development of innovative solutions for reformulating fat-containing products (Borșa et al., 2025).
Oleogelation has become one of the most widely used techniques for reducing or replacing unhealthy and controversial fats in foods (Liu et al., 2024). Various edible oleo gels are created through different methods. These are used in spreads, baked goods, confectionery, as well as in dairy and meat products (Perța-Crișan et al., 2023).
Oleo gels in food involve gelation mechanisms, while also discussing the properties of the new products (Kavya et al., 2024). Their use has led to the development of reformulated food products that are acceptable and have technological and rheological characteristics like those of traditional products, or even functionally improved. However, there is still a significant need to optimize the methods (Guo et al., 2022). Oleogels are obtained from oils derived from plant raw materials such as canola, sunflower, corn, soy, olives, flax, sea buckthorn, grapes, rice bran (Figure 3).

Oleogel - based meat products

Oleogels are widely used in the food industry for creating innovative products (Ye et al., 2019). We can identify oleogels in pastry and confectionery products (Patel et al., 2014; Mert et al., 2016), dairy products (Huang et al., 2018), and meat products (Pușcaș et al., 2020). Oleogels are used both for replacing trans and saturated fats and for their important role as carriers of water-insoluble substances, heat resistance, and stabilizers in products without emulsifiers (Pușcaș et al., 2020; Nacak et al., 2021). The characteristics of oleogels in meat products are mentioned in Table 2.

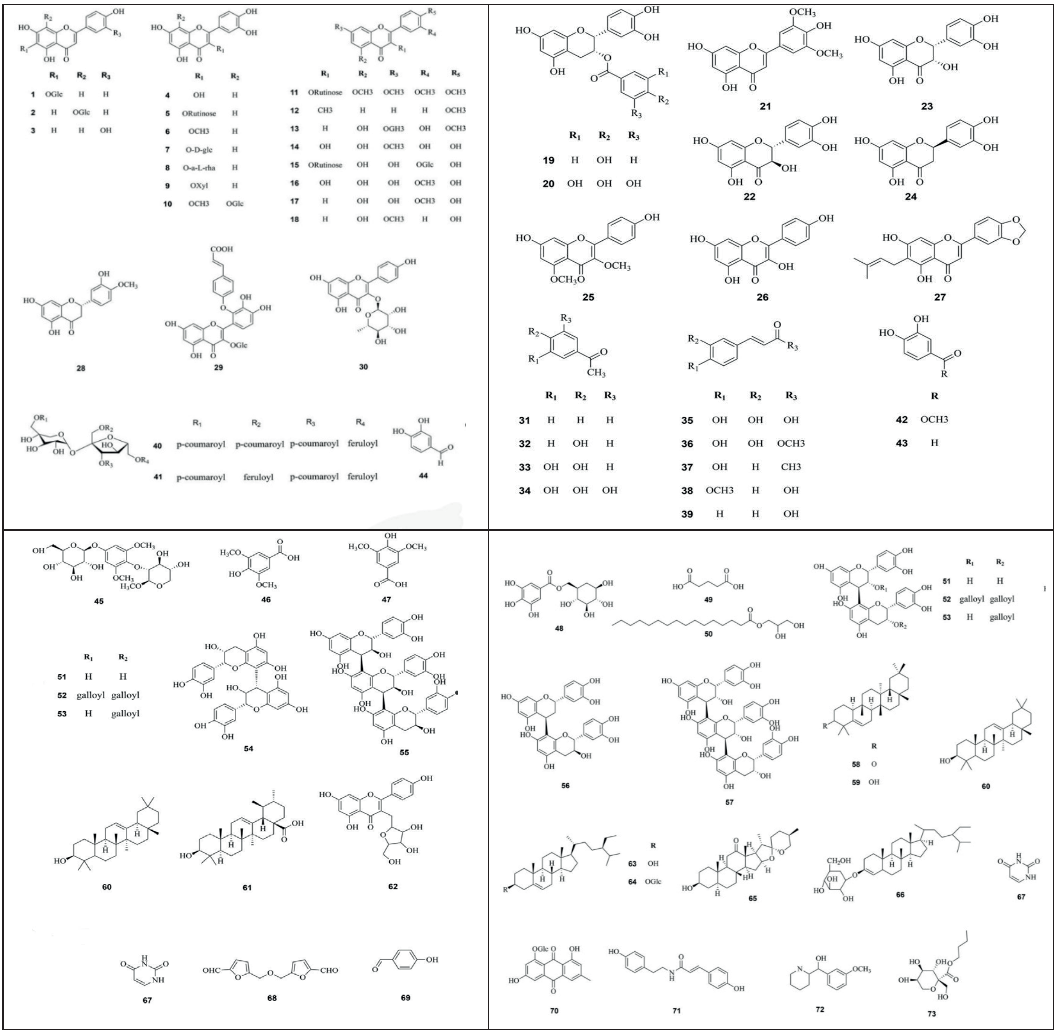

Figure 2. The chemical structures of the isolated components from buckwheat (*Fagopyrum debtors*) (Zhang et al., 2021)

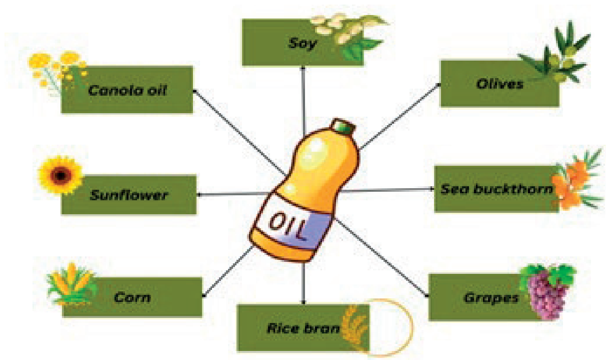

Figure 3. Different oils used for food oleogels (Perța-Crișan et al., 2023)

Table 2. Oleogels used in m eat products (Pușcaș et al., 2020)

The types of Oleogels analyzed and their references	Meat products	
	Structuring Strategy	Conclusions
Oil of gelled sunflower oil with 20% monoglyceride and phytosterol blend (Kouzounis et al., 2017)	Direct dispersion of oleogelators in oil, followed by cooling to room temperature	It was replaced with 50% of the fat from pork shoulder from frankfurter sausages with sunflower oil gelled with monoglycerides: phytosterols
Sunflower oil gelled with 10% or 20% γ-oryzanol and β-sitosterol (Panagiotopoulou et al., 2016)	*Y-oryzanol and p-sitosterol* were added to the oil at an elevated temperature and maintained at 90-120°C for 30 minutes under constant stirring, followed by cooling.	50% oleogel was used, replacing the fat from the pork shoulder in the Frankfurt sausages.
Oleogel gelified with 8% beeswax (Franco et al., 2019)	Direct dispersion of beeswax in oil, followed by cooling to room temperature	25% and 50% pork back fat replaced with oleogel in Frankfurt sausages, without affecting the texture
Canola oil gelled with hydroxypropyl methylcellulose (Oh et al., 2019)	Approaching the structure of foam	The 50% replacement of beef tallow in meatballs was generally acceptable
Gelified olive oil with soy protein concentrate and mineral water, replacing 15%, 25%, 35%, 45%, and 55% of the pork (Utrilla et al., 2014)	Olive oil, soy protein concentrate, and mineral water in a 10:1:8 mixture was emulsified	25% of the pork meat replaced with oleogel in salchichon-type sausages resulted in a new product

The meat business is undergoing transformation because of the experimental findings from the examination of meat products that contain oleogels. These goods may serve as a substitute for technological and nutritional input (Bot et al., 2011).

The quality parameters of the products, which must preserve the traditional recipe in newly developed dishes, have a significant impact on consumer preferences (Grasso et al., 2014).

Meat products' structure and flavour are influenced by fats, which also affect their stability, texture, and binding qualities (Pehlivanoğlu et al., 2018). It is crucial that the new formulation preserves the distinctive qualities of traditional beef products since quality factors affect consumer preferences (De Oliveira et al., 2012).

The potential use of oleogels as a healthier substitute for meat has been examined to create meat products with a better nutritional profile and less saturated fat (Bourne, 2002). Without affecting the finished product's physicochemical and sensory qualities, these lipid structures can either completely or partially replace fat (Martins, 2019). The interaction between the meat proteins and oleogel, however, may cause some changes in texture and consistency, which could result in the creation of a more rigid protein matrix in the finished product (Pintado et al., 2020).

Oleogels made from canola, soybean, and flaxseed oils and structured with 10% ethyl cellulose of different molecular weights provide a pertinent example. Therefore, the use of oleogels based on vegetable oils structured with ethyl cellulose can serve as a viable and healthy alternative to traditional solid fats in the food industry, contributing to the improvement of the nutritional lipid profile of products (Álvarez et al., 2011; Barbut et al., 2019). The viability of this strategy has been confirmed by experiments that found that substituting all the beef fat in the frankfurter recipe produced a product with a texture comparable to the traditional version (Barbut et al., 2016).

Using oleogels made from sunflower oil and structured with phytosterols like γ-oryzanol and β-sitosterol at 10% and 20% concentrations was another tactic. In this instance, the reformulation increased the overall lipid content by using oleogel emulsions in addition to partially be substituting fat. The results of the investigation revealed that the frankfurters' texture did not significantly alter and that the pH and lipid oxidation levels stayed within ideal bounds. The chewability and hardness of the product were impacted by the softer consistency of the varieties that contained oleogel emulsions. Although some emulsion samples were thought to have a distinct texture from the original version, the products were generally highly received in terms of sensory rating.

The replacement of pork fat in frankfurter sausages was the subject of another investigation (Zetzl et al., 2012). A structured oleogel composed of a 3:1 ratio of monoglycerides and phytosterols was used in these sausages. With this composition, 50% of the pork fat could be substituted without noticeably lowering the product's quality. Compared to oleogels made entirely of monoglycerides, the combination of monoglycerides and phytosterols produced a more robust network with better hardness, stability, and melting temperatures (Ioniță-Mîndrican et al., 2022).

The cohesiveness and elasticity of the reformulated banger recipes were comparable to those of the original recipes; nevertheless, variations were observed in terms of gumminess, brittleness, and hardness. The new goods' acceptability was validated by sensory evaluation, and there was no discernible change in the oxidation levels.

To produce a healthier alternative to typical pork, a sort of salchichon sausage made from deer meat was made using an oleogel based on olive oil that was emulsified with soy protein and water. Several salchichón samples were made, with the control version comprising 25% pork and 75% lean venison. Pork was progressively substituted in the oleogel samples at 15%, 25%, 35%, 45%, and 55% (Beriain et al., 2011). As anticipated, the content of monounsaturated fatty acids increased with the amount of olive oil oleogel (Bloukas et al., 2002).

The analyzed and reformulated samples with oleogel exhibited similar physicochemical properties during baking, including mass loss, pH, water activity, and instrumental color analysis. Additionally, the degree of lipid oxidation and the acidity index remained within acceptable limits, confirming the product's stability (Davidovich-Pinhas, 2016; Mei et al., 2006). All types of salchichon reformulated with oleogel were considered acceptable, but those that replaced up to 25% of the pork meat received the highest scores from consumers (Yu et al., 2012). This suggests that there is an optimal threshold for substituting animal fats, so that the texture and taste remain appealing to consumers. The oleogel-reformulated salchichón contained twice as much oleic acid compared to the traditional recipe (Utrilla, 2014). This aspect highlights the nutritional benefits of using oleogels, contributing to a healthier lipid composition by increasing the content of unsaturated fatty acids. Following the study, the gelling of olive oil with soy protein concentrate and mineral water was used to replace 15%, 25%, 35%, 45%, and 55% of the pork (Utrilla et al., 2014). The formulation with 25% substitution proved to be the most effective, resulting in a new type of salchichon product that was well accepted by consumers. Therefore, the use of oleogels in the reformulation of salchichon allows for the partial replacement of animal fats, maintaining the physicochemical stability and acceptability of the product. The optimal level of pork fat substitution seems to be 25%, ensuring a balance between improving the lipid profile (more oleic acid) and maintaining the texture and flavor desired by consumers. This confirms that oleogels represent a viable and healthy alternative in the food industry for reducing saturated fats in meat products.

CONCLUSIONS

According to the analysis of the specialised literature, adding buckwheat to smoked sausages has a favourable effect since it enhances the nutritious value of the product. The balanced spectrum of key amino acids found in buckwheat proteins can improve the sausages' nutritional value. Furthermore, fibre can aid in improved digestion, and antioxidants such rutin support the preservation of lipids' oxidative stability, hence prolonging the product's shelf life.

In addition to its nutritious value, buckwheat affects the smoked sausages' texture. It can improve the product's juiciness and tenderness and give it a more palatable consistency because of its capacity to absorb water. Buckwheat's high starch content also helps the ingredients stay cohesive by strengthening the bonds between them and keeping the sausages from breaking.

When animal fat is partially or completely replaced with oleogel—which is made by structuring sunflower, canola, flaxseed, soybean, and olive oils—the amount of stearic and palmitic acids is greatly decreased, the amount of linoleic acid is increased, and the organoleptic profile of fatty acids is improved—all while preserving good organoleptic qualities.

The overall fatty acid profile improved as the amount of monounsaturated fatty acids and polyunsaturated fatty acids rose. The microstructure of the semi-smoked sausages was not significantly altered by the inclusion of oleogels.

In order to produce healthier sausages with better fatty acid profiles and sensory qualities, it is therefore possible to suggest using oleogel in place of pork fat.

As a result, these developments mark a significant advancement in the creation of more accessible and nutritious food items that meet contemporary dietary needs.

The evidence provided leads to the conclusion that goods with additional plant proteins are now a viable substitute and, more importantly, essential for maintaining customers' nutritional balance. These products stand out due to their nutritional qualities.

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